CHILD DEVELOPMENT

VOLUME I

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Excellence of Production and Types of Movements in Drawing

CHARLOTTE RICE

THIS paper reports an analysis of the type and direction of lines chosen by children[1] in the copying of the Binet-Simon diamond in both vertical and horizontal positions and under varying conditions.

Although much observation and no little experimental work has been carried on in the field of children's spontaneous drawing, very little if any work has been done on the factors involved when a child sits down with the definite task of copying something set before him. And what analysis has been done on experimental results of the latter sort has been to the end of evaluation of the results in terms of adult ideals of perfection. No small part of this work has been done in the field of education through experiments in teaching beginners to write as illustrated by the reports of Huth (3) Gates and Taylor (1) Hertzberg (2). Other studies to a large extent are confined to the comparison of the orientation and similarity of the child's finished product to the pattern from which it is copied, notably by Stern (5) and Paula Meyer (4). Among none of these experiments and observations has there been any attempt on the part of the experiment to obtain an idea of the manner in which the child did the actual manipulation of the materials to get the result.

In 1926 Wellman, defining the directions of the lines to be drawn, made a very careful analysis of the influence of direction of movement on the control of hand and arm in a group of young children. She found certain directions of movement (↘ and ←) in general much more difficult than others. But so far as the writer has been able to determine, no work has as yet been done in the actual choices of kinds and directions of strokes made by young children in their attempts to copy plane figures, and the relation of these choices to the perfection of the result as judged by an adult standard, which is unfortunately the only standard available at present for such judgment.

DESCRIPTION OF TEST

The materials for the test consisted simply of a white card, 4 by 5 inches on which was a black ink drawing of a diamond $2\frac{3}{4}$ inches (long axis) by $1\frac{1}{2}$

[1] The investigation was made in the Psychology Laboratory of the Johns Hopkins University in 1928 and 1929 supplemented by data obtained in a summer at the Institute of Child Welfare, Minnesota. The author is making a further study at the University of California of the child's judgment of the excellence of the production.

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inches (long axis) by $1\frac{1}{2}$ inches (short axis), pencils, and paper for the use of the subject in drawing. Slips of paper torn from pads 3 by 5 inches proved satisfactory for this, by furnishing a size and shape somewhat comparable to the pattern card and convenient for filing. The child was seated comfortably across the table from the experimenter and was shown the pattern with the instructions:

> Do you see this (pointing to the figure but being careful not to trace it)? See what a nice picture you can draw for me that looks just like this.

At the same time the slip of paper was layed on the table in front of him in the same position as the pattern card and he was given the pencil. The position and manner of presentation of the pattern card differed at different times according to the demands of the experiment. In the case of all subjects the first exposure was in the horizontal position and according to the instructions given above.

With a certain number of the subjects (groups A, B and C) to be designated below, this procedure was followed immediately by a presentation in the vertical position with the same instructions. Later the same day, after the intervention of a test of recognition of similar forms in which the diamond played a somewhat important part, 2 presentations were given 1 in the horizontal position and 1 in the vertical with a slight change in the manner of exposure. Instead of being asked to copy the figure directly, the child was presented with the pattern card without pencil and paper, and with the following instructions:

> I want you to keep looking at this until I take it away. Pretty soon I am going to take it away and hide it, and then I want you to draw me a picture that looks just like it.

If the child's attention wandered, he was admonished to keep looking at the picture. After ten seconds the pattern was taken away, and placed out of sight, while the experimenter said,

> Now I'm going to take it away and hide it.

Then, while giving the child a pencil and placing a slip of paper before him in the same position as the pattern card, the experimenter added:

> Now see what a nice picture you can draw me that looks just like the one you have been looking at.

In the cases of groups A and B this procedure was followed some time later (in the case of A exactly two weeks; in the case of B periods ranging from fifteen to twenty-four days) by an experiment in which the child was placed before a table over which a screen was set, in such a position that the child could draw under it freely, but at the same time could not see what he was doing if he sat in a normal drawing position. The child was then asked whether he remembered what the picture looked like that he had drawn for the experimenter at the previous period. No matter what his answer, he was given a piece of paper under the screen and a pencil was placed in his drawing hand, while the other hand was placed on the paper to hold it in position. At the same time the following directions were given:

Now I want you to put this hand here to keep the paper from slipping over the table (placing other than drawing hand), and I want you to take your pencil and place it ready to start drawing, but do not draw anything until I tell you what I want you to do (placing the drawing hand with the pencil in it). Now I want you to sit up straight, and look right here (pointing to a place on the upper side of the screen directly in front of the child's eyes), and then, without looking at what you are doing under the screen,—looking right here all the time (pointing again to screen), I want you to draw the same picture you drew for me last time.

No suggestion was made that the figure be drawn in one position rather than another, aside from the fact that the paper was placed before the subject in the horizontal position. Since, however, the child could not see it, even this probably had little to do with the manner in which the drawing was made. Care was taken also to place the drawing hand in as relaxed a position as was possible lest some muscular tension due to the position should in some way influence the direction of the line.

A fourth group of subjects (group D) followed their initial drawing immediately with a group of 10 practice drawings of elements of the figure. At the end of this series the initial stimulus was given again in the horizontal position and the directions were repeated.

A fifth group (group E) followed the procedure of group D exactly, but two months later, with no intervening tests of this nature they were presented with the pattern card in the vertical position and were given identical instructions to those given at the initial presentation.

A sixth and final group (group F) followed the initial drawing, after a period varying from one to eighteen days, with a presentation of the pattern card in the vertical position and a repetition of the initial instructions.

After each drawing, no matter what the conditions under which it was made, a record was placed on the paper of the direction and order in which the lines were drawn. Although times were recorded for each drawing, they have not been treated in the present article, since they only bear indirectly on the point under discussion. The use of the Binet-Simon diamond in this experimentation is not comparable to the use of the diamond in the Binet-Simon scale test, inasmuch as in the latter case the instructions call for the exlusive use of the pen in drawing. Since the aim in the present case was to simplify the task as far as possible in order to reduce distracting factors and facilitate the naturalness of the situation to the child, a pencil, a more familiar tool to the very young child was substituted for pen.

SUBJECTS

The subjects, 293 in all, have already been divided, with respect to the particular procedures which were followed in giving the test, into groups A to F respectively. Table 1 will give the numbers, sources, ages and I.Q. scores in each group. With a few exceptions the children came from professional and better class business homes, and are the type found in good private schools. They show a wide age range, fairly evenly distributed over the years 3:1 to 8:0 and with a sufficient number of scattered cases at the

two ends of the age scale to give interesting indications of reactions at the ages not covered so thoroughly.

TREATMENT OF DATA

1. Scoring results by degree of similarity to pattern

Before analysing the types of movements made by children in drawing a particular figure, which in this case happens to be a diamond, some scheme must be devised whereby the drawings made by the child may be judged with regard to their similarity to the pattern set. To this end the diamonds have been given scores of 1, 2, 3, 4, and 5 points according to their excellency of form. Illustrations are given in figure 1. A score of 1 is given when no attempt to make a copy is evident. This is a usual reaction among the youngest children and almost invariably denotes a lack of understanding of the problem as it is presented. With an understanding of the problem, but a still deficient ability to carry out instructions, the result is a curved line enclosing a space. This is given a score of 2. A score of 3 is given when there is an attempt to produce and a certain degree of success in producing certain of the isolated characteristics which form the diamond, such as straight line boundaries and angles, which begin to narrow the limits of this figure's similarity to others. With the evolution of an inferior diamond, a score of 4 is given. For this score there must be four sides and four angles and a semblance of symmetry, though details of relation, proportion and orientation may be overlooked. With good proportion and

TABLE 1

Subject sources, ages, and I.Q. scores

GROUP NO.	SOURCE	AGE RANGE	MED. AGE	NO. I.Q.	I.Q. RANGE	MED. I.Q.
A 18	Child Institute, Johns Hopkins University	2:7–5:0	3:7	10	104–141	121
30	Park School, Baltimore, Md.	4:4–8:0	6:9	15	104–125	115
78	Roland Park School, Baltimore, Md.	3:9–9:3	6:0	46	93–145	114
B 5	Child Institute, Johns Hopkins University	3:1–4:7	3:5	5	78–116	105
5	Park School, Baltimore, Md.	4:1–9:0	4:11	2	117–130	
13	Roland Park School, Baltimore, Md.	4:8–6:11	6:4	7	92–134	116
C 1	Child Institute, Johns Hopkins University	4:3		1	135	
22	Park School, Baltimore, Md.	4:4–7:11	5:9	5	91–110	110
13	Roland Park School, Baltimore, Md.	5:2–7:11	7:1	7	105–154	116
D 3	Child Institute, Johns Hopkins University	3:11–4:8	4:0	3	111–118	117
35	Park School, Baltimore, Md.	4:10–11:2	8:1	35	87–144	113
4	Special examination, Johns Hopkins University	4:2–14:1	8:3	4	83–122	103.5
6	Children's Aid Society of Baltimore County	10:10–13:4	11:9	6	50–100	88.5
12	Graduate Students in Psychology, Johns Hopkins University					
E 11	Child Institute, Johns Hopkins University	2:9–5:3	4:2	11	91–158	130
F 31	Institute of Child Welfare, University of Minnesota	2:2–4:11	3:8	31	84–130	107

correct orientation, a score of 5 is given.

With the scale so constructed, table 2 will given an idea of its general relation to the age scale. Since all 293 subjects were given the first test, i.e., the drawing of the horizontally placed diamond from the pattern, under the same conditions, scores for this test alone are used, so obviating the tendency to modify the results which different conditions of presentation might produce. The figures in the table then, will give a good idea of the child's ability to do the task set before him at the time of beginning the experimentation.

As far as $8\frac{1}{2}$ years the figures show a steady and fairly even advance from age step to age step. Beyond this, up to the adult stage, the cases are few and scattering and all those obtaining a score less than 4 may be accounted for by some factor of retardation. It so happened that the body of systematic testing was limited to children of second grade age and below and to the small adult group. Records between the ages of 8 years 7 months and 13 years 6 months appear-

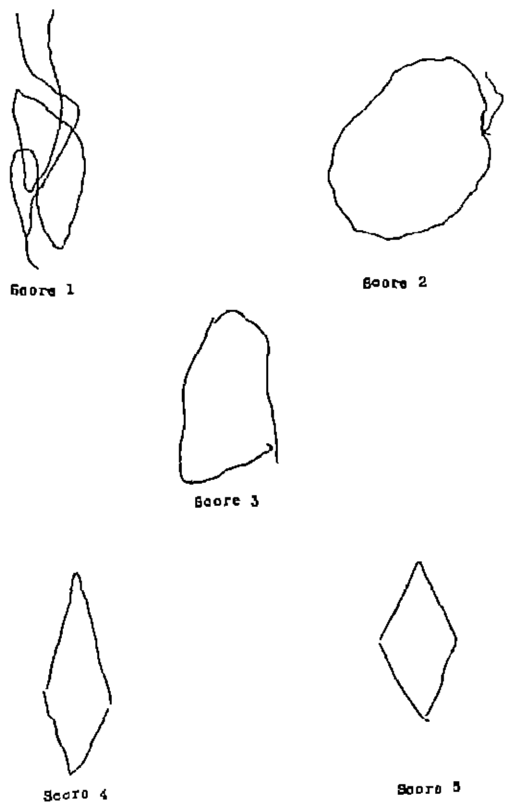

FIG. 1. ILLUSTRATIONS OF SCORINGS FOR DIAMONDS

ing in the data are taken from cases brought into the laboratory for special examination for one reason or another. Many of these turned out to be children of superior intelligence and their

TABLE 2

Distribution of perfection of performance by age: Diamond drawn from pattern in horizontal position

AGES	SCORES				
	1	2	3	4	5
2:1–2:6	4				
2:7–3:0	7	1			
3:1–3:6	9	7			
3:7–4:0	2	8	4		
4:1–4:6	5	7	8		
4:7–5:0	4	9	15	2	
5:1–5:6	0	7	9	6	
5:7–6:0	0	2	13	7	
6:1–6:6	0	1	13	16	
6:7–7:0	0	0	5	20	2
7:1–7:6	0	0	4	22	3
7:7–8:0	0	0	4	17	4
8:1–8:6	0	0	0	5	2
8:7–9:0	0	0	1	9	1
9:1–9:6	0	0	1	2	0
9:7–10:0	0	0	1	0	0
10:1–10:6	0	0	0	0	1
10:7–11:0	0	0	0	1	4
11:1–11:6	0	0	1	0	1
12:1–12:6	0	0	1	0	0
12:7–13:0	0	0	0	0	2
13:1–13:6	0	0	1	0	0
Adult	0	0	0	1	11
Total.....	31	42	81	108	31

scores all fall on 5. The others are of interest mainly in giving added material in proof of the relation of this activity to physical and mental development and to the development both of perception and motor coördination. If we consider individually all the cases between 8 years 7 months and 13 years 6 moths which fall below a score of 4, we find the following facts to be true. In one of these cases the records show no reason other than the objective fact that the body in question was still in the second grade at the age of 9 years 3 months. This boy, with a chronological age of 9 years 3 months and an I.Q. of 101 was quiet and reserved, and showed little interest in the execution of his task. The case in the age group 8 years 7 months to 9 years having a score of 3 is that of a boy of 9 years, still in the first grade, because of a speech defect which made it almost impossible to understand him. No Binet test had ever been given successfully to him, and at the time this test was made, his mental age was not available for comparison. The case in the age group of 9 years 7 months to 10 years having a score of 3 is that of a boy with a Binet mental age of 10 years 10 months but showing a marked lack of muscular coördination, and what we may call for lack of a better term, an inability to perceive objectivitely. He was extremely imaginative, and quite proficient in tasks of composition and verbal creation, but seemed utterly unable to create objective realities with his hands or with tools. The other 3 are all cases of retarded mental development, 2 of the I.Q. scores being low enough to throw the mental ages of the subjects below the 8 years level. In spite of this fact, subsequent attempts by these 3 subjects to draw the diamond, after practising on various elements of the figure in the interim, show performances rating in each case as high as 4 and in one case 5. These

cases present pictures of slow adaptation to a new situation, and are in marked distinction to the 2 cases showing speech and motor defects. While five or six cases are far too few from which to generalize, it is interesting to note that in each case that shows a lower score than one would expect, there is some outstanding factor which may easily account for the situation. It would be interesting to analyse a scattering of cases at the lower end of the age scale to see if superior intelligence might not be the causal factor there, but since in this particular distribution of cases there is no scattering at that end, we cannot at this time do so.

So much for a comparison of the score scale with the age scale. Further interesting material on types of factors effecting excellence of performance, as indicated by such a method of scoring, may be obtained from the summary of inter-correlations and changes in score for individuals when the conditions of operation are changed as found in table 3. Though certain of the correlations in this table are hard to interpret logically, as a rule apparent marked peculiarities may be accounted for by the scarcity of cases. For this reason the actual frequencies and directions of score changes are given in the second part of the table are more illuminating. It must be born in mind also that some of the conditions are not stated in the problem, such as the accumulative practice effect from one set of conditions to the next, which is present even under conditions where practice of drawing the elements of the figure was not included. Nor was the possibility that one figure position might be easier to draw than the other taken into consideration. Very little can be concluded from these figures aside from the fact that the highest correlation seems to be between 2 figures in opposite position, drawn under the same conditions with an interval approximating two weeks between the 2 operations. This set of conditions is undoubtedly that least en-

TABLE 3

Correlations and analyses of score changes between diamonds drawn from pattern in horizontal position and diamonds drawn under other set conditions

CONDITIONS	GROUPS INCLUDED	r	NUMBER OF SCORES		
			Same	Increase	Decrease
From pattern—vertical	ABC	.26 ± .05	130	43	18
After removing pattern—horizontal	ABC	.42 ± .04	132	23	36
After removing pattern—vertical	ABC	.58 ± .03	114	48	29
From memory—under screen—2 weeks after first test	A	.35 ± .05	64	7	61
From memory—under screen—more than two weeks after first test	B	.17 ± .10	10	1	12
From pattern—after practice—horizontal	D	.62 ± .03	46	7	7
From pattern—after practice—vertical	E	.16 ± .19	8	2	1
From pattern—2 weeks after first test—vertical	F	.83 ± .04	27	2	2

cumbered by extraneous factors such as practice effect or memory, which would tend to interfere with the correlation. We may also note—what might well be expected to be the case, that an attempt to draw from memory under a screen, two weeks or more after the first attempts gives a marked decrease in score. Since the experimentation was carried on with other ends in view than the demonstration of the effect of differing conditions on performance, the grouping of subjects is not such that reliable results may be obtained for comparison.

2. Analysis of directions and types of lines used in drawing diamonds

With a general idea in mind of the method of scoring, and the distribution of scores over the age scale, then, it will next be interesting to see what types of strokes are made by these children in drawing diamonds, and to relate the type of stroke used to the score of excellence and to the age.

After studying the performances carefully for some time, it was found that first of all the strokes could be divided into 2 main categories (1) the "continuous line," in which the pencil was not raised from the paper at any time throughout the process of drawing the figure, and (2) the "broken line," in which the outline of the diamond was divided into two or more parts, the pencil being lifted to another point on the paper between successive strokes. This transfer from one point on the paper to another was used as the distinguishing feature, and cases in which the pencil was merely lifted from the paper, then replaced in the same spot, after which the line was continued in the same direction, were considered as continuous lines rather than broken ones.

Given the 2 categories, they were further subdivided with respect to the direction in which the lines were drawn. With the continuous lines this resulted in divisions into clockwise and counter-clockwise strokes. With the broken lines the divisions were with respect to progress of the line to the right, the left, up or down. In general these classifications were dependent on the point to which the pencil was returned before starting the second stroke of the broken line. For example, if the child started drawing at the left hand point of the diamond as it lay in the horizontal position, drew 1, 2, or 3 sides of the figure with a continuous line, then raised his pencil and moved it to the initial point of departure again before drawing the remaining sides, the general direction of the lines of the figure was from left to right, and the diamond is tabulated under the heading "right" in the category "broken line." Similarly if the starting point is at the top, the diamond is tabulated under the heading "down," if at the right, under the heading "left," and if at the bottom, under the heading "up."

It is necessary to say a word further with respect to the interpretation of the 2 major categories in the case of a score of 1, which, it will be remembered, is the score given when the product is nothing but a scrawl. In this case, continuous line may be interpreted to mean a line of roughly circular or oval direction, while broken line includes not only the type of scrawling in which the pencil is often raised from

the paper and in which the lines show no curves, but also the modified type of scrawling which occurs when the child makes only one or two separate lines on the paper. Illustrations of scores in relation to direction and continuity of stroke are given in figure 2. At the outset, there was a question in the mind of the experimenter whether these latter types, especially the last, might not be more mature reactions to the situation than the mere circular scrawl, as also, the broken line drawing of the diamond, a more mature performance than the continuous line.

At some future date, with a much larger body of data with which to deal it will be interesting to analyse the figures which are drawn with broken lines with respect to the manner in which the lines are broken, i.e., whether the first stroke consists of 1, 2, or 3 sides of the diamond, whether the pencil is lifted and transferred only once or more than once in the process, etc. At present such an analysis is

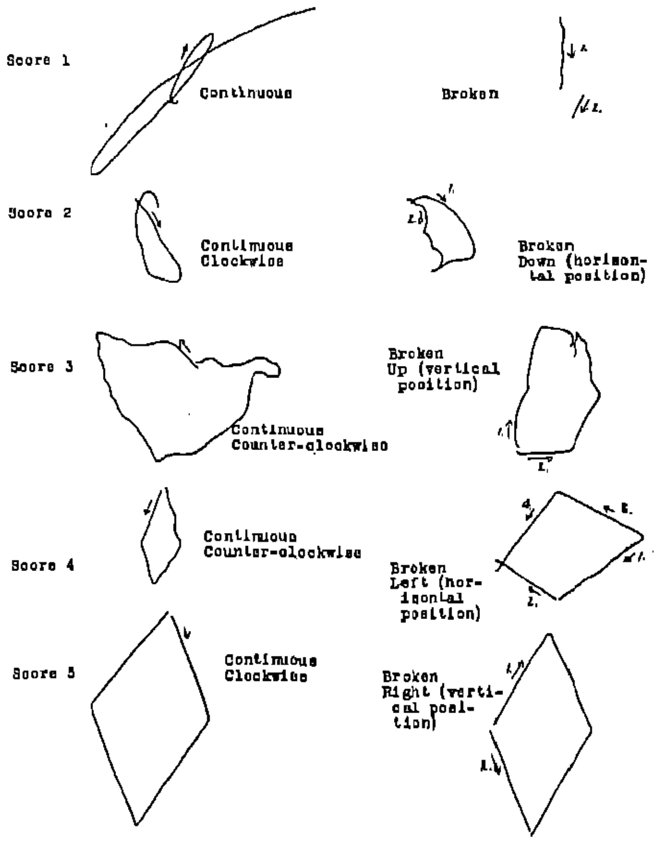

FIG. 2. ILLUSTRATIONS OF DIRECTIONS IN WHICH LINES MAY BE DRAWN

unjustified. The data are too few, and the subjects are not evenly enough distributed over the age levels.

With these factors in mind let us proceed to examine the data under the first 2 main categories, continuous and broken lines. Table 4 gives the frequencies for continuous (column headed C) and broken (column headed B) lines for each score on the diamond, under the varying conditions of the problem. It is interesting to note that under 4 of the 7 conditions of procedure, the trends of highest frequency follow exactly that of the totals as given in the last column, score 2 being the only one in the series which shows a higher frequency for continuous lines than for broken lines. This is easy to understand when we consider that this score represents a circular line or lines enclosing a space. Considering the fact that this score has already been justified as the most immature except for the scrawl, by its position on the age scale, and that the relative difference between the continuous and broken types of drawing increases progressively for the last three scores, it is easy to conclude that as excellence in performance increases, the tendency to draw the figure with a broken line takes precedence over the tendency to draw it with a continuous line. The fact that the broken line gets the majority in score 1 under every condition but 1 is explicable on the grounds that the terms continuous and broken stand for slightly different performances under this score than under the others. It indicates merely that when asked to draw something before they have reached the age when hand and arm muscles can be controlled by perception, children are more apt to scrawl in straight or angular lines than in circles. It is barely possible that this is a first step at imitation of the more controlled motions which an adult uses in drawing. If it is, however, a more advanced state than the circular scrawling it is not justified as such by the relative age distributions of the 2 types of scrawling which appear in these data. In further consideration of the

TABLE 4

Frequencies for continuous (C) and broken (B) line types of drawing for each score under the varying conditions of the problem

SCORES	HORIZONTAL—*FROM* PATTERN		HORIZONTAL—AFTER REMOVING PATTERN		VERTICAL—*FROM* PATTERN		VERTICAL—AFTER REMOVING PATTERN		FROM MEMORY UNDER SCREEN		HORIZONTAL—FROM *PATTERN* AFTER PRACTICE		VERTICAL—FROM *PATTERN* AFTER PRACTICE		*TOTAL*	
	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B
1	15	16	5	8	3	0	4	8	7	19	3	3	11	7	48	67
2	32	10	19	1	22	0	16	4	15	0	4	1	15	2	129	18
3	29	52	28	47	18	35	24	41	38	39	6	9	1	2	144	225
4	41	67	21	55	24	61	20	45	20	18	15	8	1	3	142	255
5	6	25	1	6	6	16	2	27	0	1	5	17	0	0	20	92
Total....	123	170	74	117	73	118	60	125	80	75	33	38	28	14	477	657

table under discussion, let us examine the 2 columns which deviate most from the total, with a view to determining, if possible, reasons for the deviations. The first of these, which represents the data gathered from drawing the diamond from memory under a screen shows at no place in the 3 highest scores a marked difference between the frequencies. This is undoubtedly due to the opposition of 2 factors, (1) the afore-mentioned tendency with developing excellence of performance to swing over to the broken line method of drawing and (2) in opposition to this the inability without the aid of vision to get back to the initial starting point from some other point on the page. The second of these variations, representing the data gathered from drawing the diamond from the model in the horizontal posi-

TABLE 5

Frequencies for continuous (C) and broken (B) line types of drawing for each age level under the varying conditions of the problem

AGES	HORIZONTAL—FROM PATTERN		HORIZONTAL—AFTER REMOVING PATTERN		VERTICAL—FROM PATTERN		VERTICAL—AFTER REMOVING PATTERN		FROM MEMORY UNDER SCREEN		HORIZONTAL—FROM PATTERN AFTER PRACTICE		VERTICAL—FROM PATTERN AFTER PRACTICE		TOTAL	
	C	B	C	B	C	B	C	B	C	B	C	B	C	B	C	B
2:1–2:6	2	2											2	2	4	4
2:7–3:0	3	5	1	2	1	2	1	2	1	2	0	1	2	3	9	17
3:1–3:6	12	4	8	2	0	1	8	2	3	7	0	0	5	1	45	17
3:7–4:0	8	6	3	0	2	1	2	1	1	2	4	1	7	2	27	13
4:1–4:6	8	12	3	10	6	7	6	7	6	4	2	1	5	2	36	43
4:7–5:0	17	13	8	10	10	8	9	9	9	4	4	1	7	2	64	47
5:1–5:6	14	8	11	6	10	7	7	10	5	8	2	3	0	2	49	44
5:7–6:0	5	17	4	13	2	15	3	14	2	6	2	3			18	68
6:1–6:6	13	17	10	15	8	17	7	18	14	11	4	1			56	79
6:7–7:0	8	19	6	21	6	21	5	22	11	13	0	0			36	96
7:1–7:6	14	15	10	17	11	16	8	19	11	8	1	1			55	76
7:7–8:0	7	18	6	17	6	17	7	16	12	7	1	1			39	78
8:1–8:6	1	6	1	1	1	1	1	1	1	1	1	4			6	14
8:7–9:0	5	6	3	2	1	4	2	3	3	2	2	4			16	21
9:1–9:6	0	3	0	1	0	1	0	1	1	0	0	2			1	8
9:7–10:0	0	1									0	1			0	2
10:1–10:6	0	1									0	1			0	2
10:7–11:0	1	4									2	3			3	7
11:1–11:6	0	2									1	1			1	3
12:1–12:6	0	1									1	0			1	1
12:7–13:0	1	1									1	1			2	2
13:1–13:6	1	0									1	0			2	0
Adult	3	9									4	8			7	17
Total....	123	170	74	117	75	118	66	125	80	75	33	38			477	657

tion after a practice period on drawing elements of the diamond, also has obvious factors which confuse the issue. The experiment, because of the use of the elementary parts, was drawn out to a much longer duration than the experiments carried on under other conditions. The material, after the first novelty was worn off, contained little of interest to the child and the possible factor of fatigue or boredom resulted. The child's aim frequently seemed to be to see how quickly he could finish and leave. This resulted in a more careless performance and may have been an important factor in the increase of continuous line drawings over broken line. On the other hand, in the case of children whose attention held, the practice on elements of the diamond often facilitated the drawing of the final figure. In such cases the use of the continuous line was an actual advance in skill over the use of the broken line.

In short these 2 sets of conditions so obviously modify the results that they need in no way alter the more general conclusions offered above.

Let us consider now table 5 which analyzes in a similar manner the frequencies for continuous and broken lines for each age level under the different conditions of the problem. This gives a very similar picture to the one just examined,—in general, the columns for the individual conditions of performance following quite closely the trend of the column of total responses. Here we have what might be called an uncertain period, between the ages of 3 and 6 years when the trend lines vacillate between the continuous and broken types of lines for some little time before going finally over to the broken type for the rest of the age range. This period coincides with the period on the age scale of greatest frequency for score 3, as may be seen by comparing table 2, a typically intermediate score. The factors causing the variations in the data of col-

TABLE 6

Frequencies of directions of lines in both horizontal and vertical figures, by scores

SCORES	HORIZONTAL						VERTICAL					
	C		B				C		B			
	Clockwise	Counter clockwise	Left	Right	Up	Down	Clockwise	Counter clockwise	Left	Right	Up	Down
1	12	11	3	11	1	12	14	4	1	4	4	12
2	42	24	1	4	2	5	31	26	0	2	1	3
3	41	46	6	60	4	56	25	32	3	14	9	76
4	51	35	14	37	3	82	24	32	4	16	5	93
5	11	1	1	26	0	21	6	2	1	6	0	37
Total	157	117	24	138	10	176	100	96	9	42	19	220
Total of left hand drawings	0	9	10	4	3	7	4	8	3	3	2	11

umns headed "From memory under screen," and "Horizontal—from pattern after practice" in table 4 are very evidently at work in this grouping of the data as well and may account for such discrepancies as seem to occur in the trends of the two columns in question. Aside from these deviations the same general tendency is obvious in this table,—a gradual change from the continuous line to the broken line as a means to drawing the diamond with the increase in age.

There remains then only to analyse the types of lines in further detail with regard to their direction.

For this purpose a division of the data according to conditions of procedure seems but a confusing complication. The factors at work have already been demonstrated in the previous analysis and can show nothing further if carried over into the finer differentiation, nor will any point be gained by a further analysis of types of line with reference to age groups. On the other hand, a division of the material into horizontal and vertical presentations is obviously much to the point, since a person is quite apt to draw a figure the long axis of which lies vertical, very differently from a figure, the long axis of which lies horizontal, and a pooling of the results of the 2 types would lead to erroneous interpretation. To this end the great majority of the data are already divided by the conditions of presentation. But in the case of the diamonds drawn from memory under a screen no such division exists and they must be separated by inspection. When this is done we find that of the 155 drawings made under the screen, 67 are drawn in the horizontal position, 62 in the vertical position, and 26 are mere scrawls, which can not be assigned a position and so will not be considered in this connection.

In table 6 the frequencies for each direction of line are given for both horizontal and vertical positions, by scores. Considering first only the continuous line drawings, it is evident that for the horizontal position the clock-wise motion is consistently more frequent than the counter-clockwise with the exception of 1 score level. This difference is not so marked in the vertical position, in fact there is hardly enough difference in the latter to warrant its assumption. On the other hand, turning now to the broken line drawings, preference of right over left motions and of downward over upward in both positions is very strikingly consistent and marked. It is also noteworthy that while down motions show the highest frequencies for both positions, they are much higher in comparison to all other motions in the vertical position than in the horizontal. It may be concluded then, that while clockwise motions take doubtful precedence over counter-clockwise, right motions take strong precedence over left, and downward motions take strong precedence over upward. The latter fact is extremely interesting in the face of Wellman's results. She found that lines drawn upward, on the diagonal from right to left tend to show least deviation from a true straight line. While it may be possible for the child to obtain a good result in this direction, it is quite

obvious that he does not often choose it when other possible lines are available.

Hoping to gain still further information on the matter the writer next isolated all the left handed performances from the right handed. The totals for these by type of lines used appear at the base of the table. As might be expected, the relative relation of downward motions to upward remains much the same while the relation of right to left tends quite obviously to reverse and the relation of clockwise to counter-clockwise tends more doubtfully to do the same.

Finally, there seems to be little or no relation between type of movements made and score values.

CONCLUSIONS

In general summary of the results then, we may conclude as follows:

1. There seems to be a fairly close correspondence between increase in pointscore obtained and increase in age.

2. A general tendency is present for increase in excellency of production as indicated by increase in score to be paralleled by a shift from the continuous line type of drawing to the broken line type, except when extraneous factors such as cutting off of vision during performance, fatigue, or practice effect enter in to make the continuous line type more expedient.

3. A similar tendency is evident for increase in age to be paralleled by a shift from the continuous line type of drawing to the broken line type.

4. There is a slight tendency for clockwise movements to take precedence over counter-clockwise movements in right handed performances, with a possible tendency to reversal of this relation in left handed performances.

5. There is a marked tendency for downward movements to take precedence over upward movements and for right movements to take precedence over left, in right handed performances, with a reversal of the latter relation in left handed performances.

6. Finally direction of movement seems dependent rather on the position in which the figure is drawn than on any excellence of performance.

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Psychophysiological Studies[1]

I. The Technique of Securing Quantitative and Coördinated Psychological and Physiological Data on Lactating Women in Their Usual Home Environment

HELEN A. HUNSCHER, E. LEE VINCENT, AND ICIE G. MACY

EARLY in 1924 a series of studies on the factors influencing the secretion of human milk was begun by the staff of the Nutrition Research Laboratories of the Merrill-Palmer School and the Children's Hospital of Michigan, in coöperation with the Woman's Hospital of Detroit, and later, in coöperation with the psychology staff of the Merrill-Palmer School.

The purpose of this coöperative research was to investigate the relation of physiological, psychological, and social factors to the functions of the maternal organism during the reproductive cycle. In view of the recent widespread interest in the coördination of data in various fields of study,[2] it is hoped that the results of these investigations, as they are reported from time to time, will be of use in demonstrating the integration of diverse data to secure a fairly complete picture of individuals in relation to family groups.

In coördinated studies of this type, there are 2 important methodological problems: First, the development of methods of securing the various types of data without unnecessary duplication and waste, which requires the closest possible coöperation among the advisers representing the various fields concerned, and (which is even more difficult) the securing of a specially trained worker who can secure such all-round data with accuracy and an understanding of all the factors involved and a sympathetic approach to the subjects; and, secondly, the development of methods of reducing the diverse types of data to objective and quantitative terms, with a denominator sufficiently common to permit of coördination and comparison of the data. Throughout the present series of studies, the object has been the detailed study of a small number of cases, paralleled by a study of methods of collecting and analyzing data.

The present paper reports the ex-

[1] From the Nutrition Research Laboratories of the Merrill-Palmer School and the Children's Hospital of Michigan in coöperation with the Psychology Staff of the Merrill-Palmer School, Detroit.

[2] Reports of the Home Problems Conference held at the Merrill-Palmer School, April, 1927; the Conference on Familial Relations, December, 1928; the Conference on Rural Family Relations, March, 1929.

perimental methods devised for and followed in the collection of diverse types of data on women during the periods of pregnancy and lactation, while living in their home environments, with special emphasis upon the methods followed in studying the psychological factors influencing the secretion of milk. Concerning this latter problem, which necessitates coördinated and systematic investigation in chemistry, physiology, sociology, and psychology for its satisfactory *lactation periods of the normal*, successful mother living in the home.

The authors hope that the material on the personality of the subjects and the scale for daily recording of the emotions experienced will be of interest to psychologists, and that the report will be of interest to sociologists, not only for the attempted analysis of home environment and family relations, but also as a record of data which the investigator gathered in the homes of the subjects over long periods of time,

TABLE 1
Case histories

	SUBJECT VI	SUBJECT VII	SUBJECT VIII
Age in years	27	34	29
Intelligence	Average	Superior	Low average
Parentage	Rural American	Rural American	Rural American
Number of siblings	12	4	12
Educational opportunities	Elementary school	2 years college	Elementary school
Occupation before marriage	Shop worker	Pharmacist	Shop worker
Husband's occupation	Railroad fireman	Salesman	Railroad conductor
Number of children at end of study	4	3	2
Type of home	6-room single	6-room single	6-room single
Ownership	Purchasing	Purchasing	Purchasing

solution, little besides advice in the medical literature, based for the most part on general clinical experience, is available. Scattered reports of unusual cases have in some instances led to certain concepts among physicians regarding the stimulating and inhibiting factors in milk secretion and the effects of child-bearing and -nursing upon the maternal organism, but so far as the authors have been able to learn, there has been no attempt to make a comprehensive and coördinated scientific study of the pregnancy and without exciting animosity or resistance within the family groups.

PROCEDURE

The studies were begun by observing patients in the Woman's Hospital during the lying-in period. It was found possible to gain entrance to the homes for the study of the variation in composition of breast milk in relation to the physiological activity, food, emotional reactions, and other relevant factors. After an orientation study on 4 cases at the Woman's

Hospital,[3] a more comprehensive and detailed program of observation was undertaken on 3 women. Table 1 gives the essentials of the case histories of these subjects, VI, VII, and VIII, who were studied throughout their lactation cycles in 1926–27, during the pregnancies that followed immediately in all 3 cases in 1927–28, and in the succeeding lactation cycles in 1928–29, all these periods being almost coincident in time for the 3 women.

The Human Milk Studies have been carried on in the Nutrition Research Laboratories of the Merrill-Palmer School and the Children's Hospital of Michigan, where the physiological (1–10) and clinical phases of the project have been executed. The psychological and sociological phases of the study have been supervised by the psychology and sociology staffs of the Merrill-Palmer School. Other specialists in psychology, sociology, biochemistry, nutrition, medicine, and dentistry have been consulted from time to time throughout the study.

The home contacts were made by one of the writers (H. H.) whose training was in home economics, supplemented by sociology and psychology. The entry to the home was obtained by the Mother's Milk Bureau of Detroit for the purpose of collecting samples for chemical studies on the variation in the composition of breast milk. The observer lived in the homes two days each month during twelve months of the first lactation cycle studied. She supervised the collection of milk, weighed the food eaten by the women, and noted the activities, home atmosphere, and emotional reactions of the women. She avoided the obvious rôle of an observer and assumed that of a friend in assisting with the housework and caring for the children whenever the opportunity arose. Behavior which would limit the usual home activity and conversation was avoided. There is reason to believe that within two months her presence was accepted as a matter of course by all members of the family and that thereafter the spontaneity of the individual and family behavior was uninhibited.

This worker lived in each of the 3 homes during the making of metabolic studies at intervals throughout the 2 lactation periods and 1 pregnancy period. Eight five-day studies and 1 fourteen-day study were made on each subject, thus making a total of 54 full days' residence in each home during two years. Frequent visits of several hours each were interspersed between the longer periods of residence. In addition to the infant, each family had from one to three children, who proved to be sources of information about ways of living in the family and the behavior of individuals in the family group, for they quickly reported any changes that were made in order to make a good impression upon the visitor. Frequent short-time visits were made unannounced, in order to check on the home atmosphere as observed during the scheduled visits in the home. It would seem that with so long a residence in the home and so close a contact with the family, the

[3] The authors wish to express their obligation and thanks to Edith Beck, R. N., Supervisor, for psychological observations and records kept for these preliminary cases during the hospital period.

usual and natural activities would become accessible to observation, and that it is justifiable to consider the behavior pictures of the women recorded under these conditions as fair samplings of their habitual home life.

The subjects have made unusual and valuable contributions through their continuous and untiring efforts in freely discussing their home situations, making diary reports, and keeping records of food and liquid intake, the body weights of themselves and their babies, the quantity of milk produced daily, and the daily emotional reactions. The women were accustomed to call the worker by telephone to report any unusual happenings that they believed to be of significance in the study. We feel that much of this untiring coöperation was due to the fact that the value of accuracy and the significance of the various procedures were thoroughly explained to the women, thus stimulating in them a desire for coöperation with us in the study.

The extent of this coöperation may be measured by the fact that over the period of two and one-half years, during most of which time daily or twice daily records were necessary, Subject VI returned 100 per cent of all possible records, Subject VII, 84 per cent, and Subject VIII, 100 per cent. The failure of Subject VII to return records was in itself a valuable measure, since it seemed to indicate a fundamental personality trait, similar laxities being frequently evident in her home activities.

PSYCHOLOGICAL AND SOCIOLOGICAL STUDIES

The problem of measuring the intellectual traits of the subjects was not difficult, since various fairly successful quantitative measures of intelligence have been made available during the past two decades. The Otis Group Intelligence Scale and the Detroit Alpha Intelligence Test were used.

The problem of measuring non-intellectual traits was more difficult, however, for, though numerous devices have been created in an attempt to measure such traits quantitatively, none seemed to serve adequately for such a study as this one.

The purpose of the psychological and sociological phases of these human milk studies was, then, two fold: First, that of observing the relation of the psychological condition of women to their milk secretion, and second, that of devising a plan for observing and recording daily emotional reactions and other personality traits in a specific and quantitative manner so that they could be correlated with the quantity and quality of milk produced by the subjects.

Since the inception of this project four years ago several studies on the psychophysiological relationship have been started and reported in the literature. A review of the change in attitude from the psychological to the biological as an approach to the study of personality is given by Rich (11), who has made a challenging attempt to approach the problem from the viewpoint of biochemistry. In view of this increasing interest in the psychophysiological approach it seems advisable to report at this time the methods devised for use in the present long-time study.

The case history method was used in the initiation of the project. The

periods of residence in the homes and the various visits gave the worker an opportunity to obtain such biographical material as the physical and mental background of the family, the nature of the home training, early life with siblings and playmates, and opportunities for social and educational experience. The emotional stability, honesty, optimism, psychic drive, sociability, sense of reality, extroversion or introversion, self-estimation, and self-control of the subjects were estimated by the worker after long acquaintance with them. The subjects described their own general temperament in regard to temper, general irritability and control, strength of sex urge, sociability, special talents, and emotional stability.

The 4 standardized tests[4] for the rating of personality and emotional stability which were administered yielded a general picture of the individuals and of the probable reaction of the women as determined by evaluation of usual conduct, but gave only a limited analysis of details and of changes in emotional behavior. The descriptive personality method of the case history depicts in a general manner the reaction tendencies noted by the observer. On the other hand, this method does not allow for daily variation in the nature and intensity of the reactions, a record of which is necessary to the understanding of the emotional make-up of the individual in a continuous long-time study. It was necessary, then, to devise some means of recording the daily emotional pattern quantitatively in such a way that the changes in emotional behavior might be correlated with one another and with the measurable changes in physiological behavior, e.g., the quantity and quality of the milk secreted and the chemical composition of the blood and urine.

Several methods of recording the daily emotional pattern were tried before a satisfactory one was secured. Early in the study the general ratings were supplemented by daily reports of activities and reactions made by the women themselves. These were in the form of a one-page report (Plate I) designed to record variations in emotional response as measured by the presence or absence of five emotional states, i.e., temper scenes, worry and anxiety, melancholy, hilarity, and excitement, with a small space provided for a description of the incident accompanying or causing the emotion. The results showed that this method was not practicable. The subjects lacked both the time and the vocabulary to compose a daily essay report of their emotional responses; they found it difficult to classify the adjustments of the day under the headings provided; the amount of writing required and the difficulty of classification led to incomplete or neglected reports; and frequently only one incident of the day was reported when those preceding or following it may have had more influence in determining the general emotional pattern.

To avoid some of the difficulties inherent in this form of report, the women were asked to write a narra-

[4] The Pressey X-O Tests, the Laird Personal Inventory Tests, the Social Intelligence Tests of the George Washington University Series, and the Allport Ascendancy-Submission Study.

PLATE I

Name...............

Date................

VIII. 5. *Daily Report* (One sheet each, covering 20 consecutive days)

a. Emotional picture. Record instances of:

1. Temper scenes...
....
....

2. Worry and anxiety..
....
....

3. Melancholy...
....
....

4. Hilarity...
....
....

5. Excitement...
....
....

b. Quality and quantity of milk if measured............................
....
....

c. Physical condition..
....
....

d. Relevant incidents..
....
....

tive of their daily activities and reactions in the form of a daily diary, but the lack of time, inclination, and command of expression limited the success of these accounts also. One woman with many home duties found the necessary time and enjoyed writing of her family routine and disturbances. On the other hand, another frequently found so little to write, other than "usual day," that her diaries proved useless as a record of presence or degree of emotional activity or reactions. Again, though the diary type of report provided opportunity to record and describe emotions and their stimuli, there was no way of estimating the degree of response or of classifying the records either quantitatively or qualitatively.

It was evident that what was needed was a scale which would permit the subject to rate and record her own emotional states and which would have uniform classifications and cover a definite time period, but would allow for the recording of different degrees of intensity in the emotional experience. A self-rating device was considered essential, not only because it was impossible to keep a worker in the home constantly, but also because even intimate contact with the subject might not reveal her actual feelings to the observer, owing to the fact that the adult habitually conceals certain reactions from social habit and that the difference in range of experiences in subject and observer introduces a large personal margin.

In devising the scale, therefore, the special requirements of a self-rating device were considered. Adjectives descriptive of personality traits and emotional responses were analyzed to determine those which one would most often use in describing one's self rather than another person, and this selected list was compared and combined with descriptive words used by the women themselves in their diary records. The words used in the scale are therefore those common to the layman or non-academic person, but the meanings and classifications have definite values. The words selected are descriptive not of such total personality traits as stability, self-control, good-naturedness, and the like, but of personal and specific responses to situations which are likely to vary from day to day. Care was taken to include fear, anger, joy, love, worry, and excitement, and to consider the possibility of estimating them quantitatively, since these states are especially mentioned by medical writers as factors influencing the secretion of milk.

It was believed that these daily records, kept over a long period of time, would permit a sounder judgment of total personality traits than would more subjective ratings made by either the worker or the subjects. The material obtained by the case history method was checked against these daily records, and the records themselves were checked against ratings made by the worker on the basis of both types of record.

Twelve pairs of adjectives, each pair describing opposed emotional states (e.g., *good-natured* and *cross*), appear on the scale. Each of these pairs is scaled in 5 divisions, to show the differential intensity of the emotion. Thus a check at either extreme of the 5 divisions indicates a

PLATE II

DAILY REACTIONS

Subject:
Date:

Merrill-Palmer School
Nutrition Research Laboratory

Afternoon

Energetic					Listless
Pessimistic					Optimistic
Afraid					Secure
Happy					Dejected
High-strung					Relaxed
Pleased					Disgusted
Carefree					Worried
Indifferent					Affectionate
Good-natured					Cross
Discontented					Content
Ardent					Apathetical
Tired					Rested

REMARKS: Did you lose your temper? Yes.......... No..........

Evening

Energetic					Listless
Pessimistic					Optimistic
Afraid					Secure
Happy					Dejected
High-strung					Relaxed
Pleased					Disgusted
Carefree					Worried
Indifferent					Affectionate
Good-natured					Cross
Discontented					Content
Ardent					Apathetical
Tired					Rested

REMARKS: Did you lose your temper? Yes.......... No..........

NAP IN AFTERNOON: Yes....... No.......
NIGHT SLEEP: ....Hours, Broken......., Unbroken.......
ACTIVITY: Intense......., Moderate......., Light......., Pedometer Reading.......
DREAMS: Many......., Few......., None......., Happy ...., Indifferent......., Distressing.......

marked degree of the emotion shown at that end of the scale, a check at the center an absence of either extreme, and a check in the intervening divisions (2 and 4) the presence in a minor degree of the emotion shown at the nearer end of the scale (Plate II).

The method of checking may be illustrated as follows. The pair of opposed emotional states already mentioned, *good-natured* and *cross*, are scaled:

Good-natured	1	2	3	4	5	Cross

If the subjects feels extremely good-natured, as opposed to cross, or if she "feels good no matter what happens,"[5] she will check on 1. Perhaps everything is "going wrong," she "wants to jump on the children for nothing at all," she is "truly ill-humored"—then 5, the opposite of 1, is the place to check. On the other hand, if the subject cannot distinguish the feeling described by either adjective, she will check on 3, the zero point of either good-naturedness or crossness. If the children are slightly bothersome, or the family is not going as smoothly as usual, or the subject feels "peeved," she will check on 4, the mid-point of 3 and 5. If the affairs of the day are going fairly well, with few disturbing incidents to destroy a good nature, and she does not feel extremely good-natured, but certainly not cross, she will check on 2.

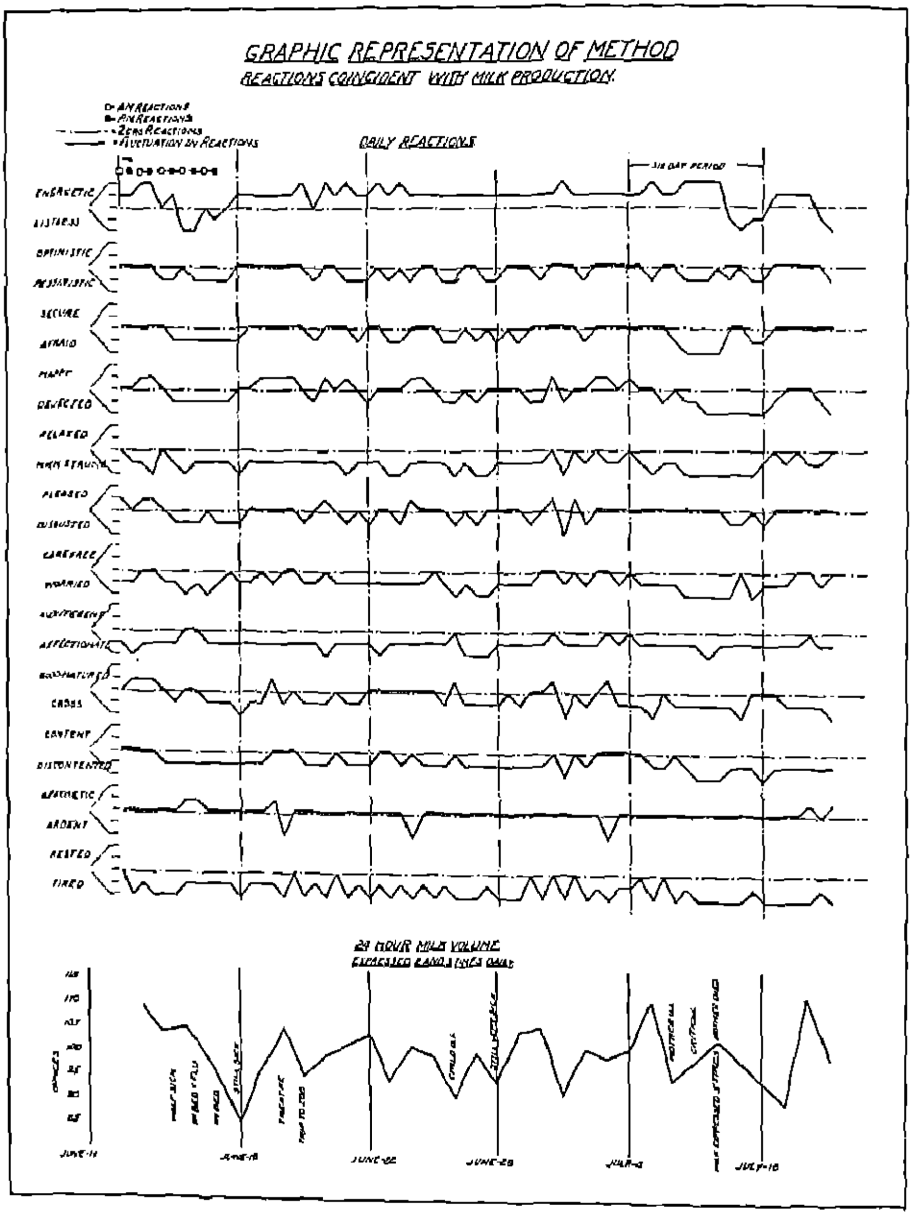
In order to offset any tendency to check consistently on one side or the other of the scale, and to prompt the thoughtful evaluation of each emotional experience represented, the placing of all the favorable emotional states on one side of the scale and all the unfavorable states on the other side was avoided.

The subjects were asked to rate themselves twice daily, at the periods when there was most likely to be quiet in the home and least demand for household activity; that is, in the early afternoon for the morning rating and in the late evening for the afternoon and evening rating. In case the subjects could not check at these times or forgot to do so, they were requested to leave the scale unchecked. Space is provided under the checking scale of each pair of traits for remarks which might throw valuable light on the checking and at the bottom of the form for the recording of other relevant factors, i.e., a loss of temper, the daily pedometer reading, the subject's own estimate of the amount of her activity, the number of hours of rest and sleep, and the amount and type of dreaming.

Several minor revisions of the scale were necessary after it had been tried long enough to indicate individual tendencies in checking among the subjects. Thus analysis of the results showed that certain adjectives caused individual subjects to check invariably on the same division of the scale, and that the substitution of another adjective descriptive of the same emotional state led to a less biased, more accurate evalution. For a period of two weeks, for example, one subject checked on the extreme of *fearless* in the pair of emotional states then described as *fearful* and *fearless*. The accuracy of these reports was questioned and it was thought that the

[5] The quotations are from the diary records of the subjects.

PLATE III


GRAPHIC REPRESENTATION OF METHOD
REACTIONS COINCIDENT WITH MILK PRODUCTION
ZERO REACTIONS
FLUCTUATION IN REACTIONS
DAILY REACTIONS
ENERGETIC
OPTIMISTIC
SECURE
AFRAID
HAPPY
DEJECTED
RELAXED
PLEASED
DISGUSTED
WORRIED
AFFECTIONATE
CROSS
CONTENT
DISCONTENTED
ARDENT
RESTED
TIRED
24 HOUR MILK VOLUME
JUNE-22
JUNE-28
JULY-10

adjectives used might have something to do with the uniformity of the report. Accordingly, the terms *afraid* and *secure* were substituted, and the subject began to show variability in this trait on the checked scale and admitted that the former terms had annoyed her and led her to check as she did.

The response of the women to the rating scale has been very satisfactory. They readily learned how to use it and have found it no burden to check twice daily. According to the subjects, the scale is complete descriptively, and they experience less inhibition in checking it than in describing their emotional experiences in diary form—an observation which is confirmed by analysis of the diary records.

In order that the material might be made more accessible for study the ratings made on these scales were recorded on graph paper, a method of analysis which permits comparison of the physiological data (the daily quantity of milk, and the chemical composition of the milk, urine, and blood) with the data on the daily emotional reaction. In graphing the ratings, the results for the intense emotions were placed at the bottom of the five-step scale, since medical literature seems to indicate that strong emotions suppress the secretion of milk and change its chemical composition. If this assumption is true, the graphic record should show a fall in milk production as intense emotions are indicated and a rise as milder emotions are evidenced, and marked variations in emotional reaction should be accompanied by changes in composition of the milk greater than the usual daily variation. An analysis of a sufficient number of such records over long periods of time should substantiate or refute theories which claim a relationship between variations of emotion and quantity and quality of milk produced. Chemical and biological studies are now in progress which will provide data for the correlation of the physiological and psychological findings.

PHYSIOLOGICAL STUDIES

The long-time psychological observations have been accompanied by comprehensive physiological studies made simultaneously on the same subjects. Physicians on the medical staff of the Woman's Hospital of Detroit examined and approved the health status of the women under investigation before the studies were begun. The family physicians have since coöperated continuously in making available all office records of the health and treatment of the women and in reporting any information that they believed to be pertinent to the studies in progress. The worker visited the physicians with the women if medical advice was sought during her visit in the home.

During the 2 lactation periods and 1 pregnancy period the women have been weighed weekly under specific conditions; their basal metabolic rates determined twice; detailed oral examination and roentgenograms of the teeth recorded at definite intervals in the reproductive cycle; and their bodily measurements and photographs taken as guides in determining their body constitutions and body types. The maternal food intake has been studied qualitatively and quantitatively in the homes. The constituents of the in-

dividual diets have been computed from accepted tables showing the composition of food materials, and the diets chemically analyzed at various intervals.

Detailed analytical studies have been made of the chemical variability of the milk of the individual women at definite intervals throughout the progression of lactation, to ascertain the quality and quantity of milk received by the infant during the process of growth and development. These determinations have included the analysis of all the milk secreted at hourly intervals throughout the day and night over a specific period of time. These studies will yield information upon the chemical composition of hourly, daily, and monthly samples of milk from the same individuals during two successive lactation periods, and upon the relative amounts of milk secreted by the right and left breasts and the relative composition of milk at the first half and last half of nursing. Biological assay of the vitamin A and B contents of the individual milks in 2 lactation cycles, comprehensive chemical analyses of the urine during pregnancy and lactation, and periodic blood chemistry studies have been made.

Periodic chemical metabolic balance studies have been made in order to observe the ability of the maternal organism to utilize the food consumed for satisfying the many demands placed upon her during the reproductive cycle, i.e., in maintaining her own physical well-being, in assuring optimal conditions for the development of the fetus in utero, and in preparing her own body tissues for the elaboration of milk to feed the infant. This information can be obtained only through studying the differences between the chemically determined constituents of the total food and liquid intakes and the total outgo of urine and feces during pregnancy, and between the total food and liquid intakes and the total outgo of urine, feces, and breast milk during lactation. These chemical metabolic balance studies have extended over five- and ten-day periods in the homes at specific intervals during the 2 lactation periods and 1 pregnancy period, during which periods the materials used for the chemical assay were collected.

The development of the infants has been followed in detail. Records of the prenatal, birth, and feeding histories, roentgenograms of the long bones for the detection of rachitic tendencies, and the course of the mental and physical development, all of which should contribute valuable data in this coördinated research, have been secured.

The data obtained in these psychological and physiological studies should furnish a basis for the further interpretation of psychophysiological relationships.

DISCUSSION

Medical literature carries the opinion that fatigue, excessive activity, and intense emotions have deleterious effects upon human milk secretion. This conception is not, however, based upon scientifically recorded observations but upon general clinical experience. The method presented herein offers an opportunity for studying the physiological manifestations of intense emotion, and the effects of fatigue in

relation to emotional reactions and milk secretion.

A graphic illustration of the method of coördinating psychological and physiological data is presented in Plate III, where the volume output of milk is studied in relation to emotional reactions. This method of recording data provides for an interpretation of widely diverse types of material. It is the purpose of this paper, however, to present a method for integrating data of various types, rather than a summary of findings with respect to the data used.

Observations have been made on the hours of rest and sleep in relation to the degree of activity. The method includes also the differential rating of the "tired-rested" and "energetic-listless" reactions, the comparative trend of the ratings made in the afternoon and evenings, and the comparative ratings of emotion reactions, such as fear, anger, joy, love, worry, and excitement, all of which are recorded simultaneously and all of which can be compared with physiological reactions. Any relationship between fatigue or emotion and the volume output of the chemical composition of the milk secreted by a woman can be noted, and the findings obtained in the chemical analysis of the blood and urine can be coördinated with the other factors rated.

The graphic representation of the quantitative psychological and physiological findings may yield information concerning certain mind-body relationships. For example, if intense emotion does affect the secretion of milk and vary its composition beyond the usual limits of variability for a given individual within a given stage of lactation, any appreciable fluctuation will be evident in the graphic record over an extended period of time. Such a variation must, of course, be in contrast to the usual emotional and physiological findings recorded. In other words, it is necessary to know the accustomed variability in the psychological, physiological, and biochemical reactions as a basis for interpreting results obtained during a period of intense emotion, or of other unusual variation.

These studies of the factors influencing human milk secretion offer a practical and successful demonstration of a technique employed in securing and evaluating quantitatively coördinated psychological, sociological and physiological data centered upon an individual within the family group.

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Inter-relationships in the Behavior of Young Children

Florence L. Goodenough

The following series of reports presents results from a coöperative experiment carried out by a group of graduate students in the University of Minnesota Institute of child welfare during the fall of 1928. The major purpose of the experiment was to develop a method whereby direct observations of specified modes of behavior might be reduced to quantitative expression on a uniformly graduated scale, and to ascertain their inter-correlations with each other and with such additional measures as might be available through other sources.

The traits selected for observation were as follows: physical activity (2 observers), amount of conversation or talkativeness (2 observers), laughter (3 observers), compliance (4 observers) and social traits including both social participation and leadership (2 observers). Thirty-three nursery school children, 17 boys and 16 girls, whose ages taken at the middle of the observational period ranged from 27 to 59 months were used as subjects. The mental age range was from 30 to 75 months with mean of 48.8 months; the I.Q. range from 77 to 170 with mean of 110.5.

In securing the original observational material the method of short samples (1) was used. Each observer secured a total of 25 one-minute observations of each subject. Each observation was taken on a different day[1] and no two persons observed a child at the same time, so that all measures were taken independently of each other. This method insures that factors incident to the immediate situation but not pertinent to the general field of inquiry will not operate to give a spurious appearance of reliability to the data; in other words, that errors of measurement will be uncorrelated.

The general procedure which was carried out by all groups was as follows: After having decided upon the particular aspect of behavior to be observed, a series of descriptive categories was built up in such a way as to form roughly graded steps from a low to a high degree of the trait in question. This preliminary scale was then tried out empirically by having the members of the group make simultaneous obser-

[1] In a small number of instances it was necessary to make two observations of a child on the same day in order to make up for losses due to absences. When this was done the two observations were always separated by as great a time interval as possible. As a rule, one was taken in the morning, the other in the afternoon. In this respect the procedure differed from that used by W. C. Olson (5).

vations on each of a number of children, classify their behavior independently and then compare the results. In most instances these first try-outs revealed inadequacies in the formal descriptions which led to disagreement in classification. When this was found to be the case, the scales were revised or the phraseology clarified and the method retested for objectivity in the same manner. This process was continued until it was found that exact agreement in classification was obtained in at least 95 per cent of the independent observations, with no disagreement greater in amount than one step on the scale. When the above degree of precision had been reached, work on the main project was begun.

So far as possible, observations were made during the free-play hours from 9:30 to 10:30 in the morning and 2:30 to 4:00 in the afternoon. In a few cases, owing to conflicts in the students' programs, these hours could not be used. The effect of such irregularities upon the consistency of the results will be discussed in connection with the papers on laughter and talkativeness.

All records were made on prepared mimeographed forms so arranged as to reduce the labor of recording to a minimum. A sample of the form used is shown in figure 1.

In the space following the words *Observation of* ——————— the kind of behavior under observation (as laughter, physical activity, etc.) was recorded. The names of the children, arranged in alphabetical order were mimeographed on the sheets in order to economize time in record taking. The second column, headed *Order of Observation* provided a space for checking the order in which the different children were observed. This order was varied systematically from day to day, since it was thought possible that certain forms of behavior

Observation of................

Date................Day................Hour................Observer.................

Notes...

....

CHILDREN	ORDER OF OBSERVATION	PLACE	OCCUPATION	SCORES (IN 15 SECOND INTERVALS)			
				1	2	3	4
A—— R—— Others							
A—— J—— Others							

FIG. 1

might show constant variational trends from beginning to end of the hour.[2]

The place of observation (playground, gymnasium, or room number) was recorded in the third column, followed by a note as to the child's occupation at the time. In the last four columns the child's behavior score was recorded at fifteen-second intervals during the minute of observation. Recording was done by means of symbols representing the various steps or categories in the scales used. Each observer, therefore, obtained 100 separate records for each child in the course of the 25 observations. The names of other children in the group with the child were also recorded for use in another study.

After the data had been collected, the results for all the children were pooled and scale values for the separate categories were obtained by the use of the formula.

$$d = \frac{z_1 - z_2}{q_1 - q_2}$$

where q_1 and q_2 are the proportions of the total number of observations lying beyond the upper and lower limits respectively of the category involved, and z_1 and z_2 are the ordinates for these proportions. (3) An arbitrary zero point of 3 sigma below the mean was assumed as the point of origin in all cases, so as to do away with negative values. Scores for each child were then computed by multiplying the frequency-score in each category by the scale value of that category, summing, and dividing the result by the total number of observations.

Individual scores were obtained upon the basis of the records of each observer separately, and also for the combined records of all observers for a given trait. The reliability of the scores was then computed by finding the mean inter-correlations between the scores of the separate observers for each trait and correcting by the Spearman-Brown prophecy formula.[3] This method may properly be regarded as a rather rigorous test of reliability, since it is based upon the extent of agreement between the records of different observers working at different times, and upon brief samples of behavior taken on twenty-five or more different days during a period of eight to ten weeks.[4] Under these circumstances, the extent to which a child maintains his position in the group may fairly be taken as an index to his habitual behavior in the nursery-school situation at the period of development under consideration.

After the series of observations had been completed, the following additional material was obtained for purposes of correlation.

1. Each observer ranked the 33 subjects in order of *physical beauty*. The ranking was done by a modified form

[2] For example, one student observed talkativeness during the lunch hour. It is not improbable that as the appetites of the children become satisfied, definite changes in the amount of conversation take place.

[3] The applicability of the prophecy formula to material of this kind had previously been demonstrated by Parten in her Ph.D. thesis (as yet unpublished).

[4] Since the members of each group made their observations on different days as far as was practicable, the actual number of days included in each series of observations is considerably in excess of twenty-five for all subjects.

TABLE 1

Intercorrelations of mental, social, and physical traits in nursery school children

	LAUGHTER	COMPLIANCE	SOCIALITY	LEADERSHIP	PHYSICAL ACTIVITY	TALKATIVENESS	BEAUTY	ATTRACTIVENESS OF PERSONALITY	MARSTON SCALE	OLSON SCALE	CHRONOLOGICAL AGE	MINNESOTA M.A.	MINNESOTA I.Q.	MERRILL-PALMER M.A.	MERRILL-PALMER I.Q.	HEIGHT	WEIGHT	LENGTH OF NURSERY-SCHOOL ATTENDANCE
Laughter	+.83 +.73	{.36 .27	{.34 .52	+.53	+.28	+.38	+.34	+.35	+.36	{.57 .43	+.45	+.41	+.07	+.40	+.13	+.35	+.23	+.48
Compliance	η	+.47 +.55	{.32 .36	.17 .30	−.37	−.33	+.19	−.10	−.20	−.11	−.31	−.34	−.15	−.35	−.27	−.31	−.13	−.40
Sociality	η	η	+.76 +.41	+.99	+.31	+.59	−.14	+.09	+.45	−.19	+.74	{.74 .83	+.08	{.72 .62	+.35	+.74	+.52	+.56
Leadership	+.33	η	+.96	+.76 +.45	+.29	+.61	−.20	+.17	+.46	−.29	+.71	+.64	+.10	+.66	+.36	+.71	+.52	+.58
Physical activity	+.17	−.31	+.15	+.13	+.66 +.65	+.25	+.06	+.17	+.28	+.17	+.29	+.21	−.07	+.29	+.11	+.26	+.18	+.24
Talkativeness	+.27	−.25	+.53	+.55	+.17	+.59 +.53	+.42	+.39	+.60	−.46	+.35	+.49	+.32	+.46	+.35	+.49	+.29	{.65 .44
Beauty	+.40	+.21	−.24	−.31	+.05	+.46	+.91 +.91	−.08	+.36	−.37	−.03	+.19	+.29	+.25	+.41	+.01	+.04	+.26
Attractiveness of personality	+.48	−.17	+.34	+.43	+.24	+.48	−.08	+.85 +.95	+.40	−.76	−.18	+.16	+.23	+.15	+.42	−.15	−.14	+.18
Marston scale	+.40	−.19	+.60	+.59	+.27	+.62	+.36	+.42	+.85 +.98	−.12	+.06	+.14	+.03	+.16	+.20	+.11	+.06	+.20
Olson scale	η	−.09	−.18	−.32	+.21	−.46	−.58	−.80	−.12	+.94 +.94	−.09	−.41	−.32	−.34	−.29	−.13	−.10	−.20
Chronological age	—	—	—	—	—	—	—	—	—	—	— —	+.78	+.00	+.85	+.24	+.85	+.59	+.58

Minnesota M.A.	+.11	−.17	η	+.20	−.03	+.37	+.34	+.49	+.15	−.55	—	— —	+.61	+.90	+.64	+.74	+.44	+.73
Minnesota I.Q.	—	—	—	—	—	—	—	—	—	—	—	—	— —	+.35	+.67	+.13	−.05	+.30
Merrill-Palmer M.A.	+.23	−.17	η	+.15	+.09	+.33	+.52	+.58	+.21	−.50	—	+.72	—	— —	+.68	+.73	+.48	+.74
Merrill-Palmer I.Q.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	— —	+.28	+.05	+.46
Height	−.07	−.09	+.31	+.29	+.03	+.39	+.07	+.01	+.11	−.10	—	+.23	—	+.03	—	— —	+.77	+.83
Weight	−.05	+.07	+.15	+.16	+.01	+.11	+.07	−.04	+.03	−.06	—	−.04	—	−.10	—	+.55	— —	+.48
Length of nursery-school attendance	+.26	−.27	+.12	+.15	+.05	η	+.38	+.42	+.34	−.19	—	+.44	—	+.42	—	+.13	+.13	— —

The first of the paired numbers within each boxed space is the reliability coefficient as computed for the entire group of cases; the second is the reliability coefficient when age is held constant by partial correlation. The reliability of the mental tests and of the two physical measurements is known to be high; but as these values have not been separately established *for this particular group of cases precise figures cannot be given.*

The values above the diagonal row of reliability coefficients are the intercorrelations of zero order; those below the diagonals are the first-order intercorrelations when age is partialled out. Coefficients enclosed in braces are correlation ratios.

of the method of paired comparisons. Each child's name was written on a separate slip of paper, and the slips were then arranged in order by comparing in turn each one with every other one.

2. Ratings of each child on *attractiveness of personality* by the method of absolute judgment were also made by each observer. A five-point rating scale was used with steps defined as follows:

a. Very delightful personality. Attracts and holds the frienship of others. Liked by both children and adults. His companionship is universally sought for.

b. Pleasing personality. Liked by most of the persons with whom he comes into contact.

c. Rather colorless personality. In general is neither greatly liked nor disliked. His companionship is neither sought nor avoided.

d. Rather unattractive personality. A few friends but not generally popular.

e. Decidedly unattractive personality. Disliked and avoided.

3–4. A copy of the Marston rating scale for introversion-extroversion, (4) and of the Olson series of ratings for the prediction of behavior problems,[5] was filled out for each child by each observer.

Data were also obtained from the nursery-school records, as follows: (1) Chronological age taken as at the mid-point of the period of observation, (2) sex, (3) mental age on the Minnesota test for pre-school children corrected to agree with chronological age at above date, (4) I.Q. on above test, (5) mental age on the Merrill-Palmer series of performance tests, (6) I.Q. on Merrill-Palmer test, (7) standing height and (8) weight, both as of above date, (9) hemoglobin test, (10) number of days' attendance at nursery school, (11) occupational status of father, (12) size of family, (13) birth order, and (14) a rating on general physical condition (excellent, good, fair or poor) given by the nursery-school pediatrician.

In order to avoid unnecessary repetition, the intercorrelations of the observational findings with each other and with the rating scale, intelligence test results, measurements of height and weight, and attendance record are presented in collective form at this point (see table 1). Their discussion is reserved for the separate reports which follow. No reliable correlations were found between either the hemoglobin test or the physician's ratings on health and any of the other variables, hence these have not been included in the table. These children, it must be remembered, were all in good health and none of the hemoglobin scores were below the standard commonly accepted as normal. Differences associated with sex and occupational class are few, and will be discussed in connection with the traits in which they occur. Size of family and birth-order appear to be unrelated to the other factors considered in this study.

PHYSICAL ACTIVITY[6]

Method. The method used in this investigation has been explained in the

[5] Unpublished Ph.D. thesis, University of Minnesota.

[6] The observations on physical activity were made by Miss Genevieve Hobart and

oregoing section. Two graduate students made the observations, using the following categories.

0. No observable activity
1. Hand and arm movements only
    a. Active
    b. Strenuous
2. Hand, arm, and trunk movements only
    a. Active
    b. Strenuous
3. Leg and trunk movements only
    a. Active
    b. Strenuous
4. Movements of the whole body
    a. Active
    b. Strenuous

"Strenuous" activity included rapid movements, or movements in which considerable energy was utilized such as sliding, rapid running, climbing stairs or ladders, lifting heavy objects, supporting the body by the hands, crawling and hanging stunts, and the like. Less energetic movements were called "active." At the end of each fifteen-second period during the minute of observation, the observer recorded the child's behavior during that time by writing the appropriate number and letter in the columns provided for that purpose.

Reliability. The average inter-correlation between the two observers was .76 and this became .86 when it was corrected by the Spearman-Brown formula. Since one student observed almost entirely between the hours of 9:30 and 10:30 in the morning, while the other nearly always made her observations between 2:30 and 4:00 in the afternoon, this figure is probably somewhat lower than would have been found if the hour of observation had been uniform. The reliability with age held constant was .85. The standard deviation of the distribution was .26.

Relationship between physical activity and other factors. Insofar as the methods employed have yielded valid measures of the forms of behavior under consideration, physical activity seems to be but slightly related to other characteristics of the children in this group. None of the correlation coefficients were as much as four times their probable error; the greater number were less than twice their probable error. The highest relationship found was a negative correlation of —.37 ±.10 with *compliance.* This drops to —.31 when age is held constant. While this finding needs to be confirmed by study of a larger number of cases, it is quite in line with the common observation that children who are most active physically are likely to be somewhat less docile than those who are more quiet. One might hazard the assumption that such a relationship, if it exists, is largely the result of the fact that the more active children are more often engaged in some definite occupation of their own, and on this account are less ready to comply with the requests and suggestions of others than children who are more frequently unoccupied. Other correlations with physical activity which may possibly be suggestive are as follows: with sociality, +.31; leadership, +.29; extroversion, +.28; attractiveness of personality as judged by adults, +.24; likelihood of becoming a behavior problem (Olson scale), +.21; frequency of laughter, +.28.

Mrs. Jean Helgeson. Mr. Robert Challman is responsible for the statistical work and for writing this section of the paper.

Although these correlations are low, they are in the expected direction.

TABLE 2

Effect of sex upon physical activity

SEX	N	M	σ	D	D/σd
Boys.............	17	3.12	.26	.24	3.00
Girls.............	16	2.88	.19		

When age is held constant, the correlations between activity and intelligence as measured either by the Minnesota or the Merrill-Palmer tests, length of attendance at the nursery-school, beauty as rated by twelve judges, height, weight, size of family, position among siblings, social status as indicated by occupation of father, and a physician's rating on general health are all lower than their probable errors.

Support for the common belief that boys are more active than girls is, however, found in this study. The boys' mean for physical activity was 3.12, the girls' mean was 2.88. This is a significant difference as table 2 shows.

There is also a differential effect of age upon physical activity when sex groups are used. Disregarding sex, the correlation between C.A. and physical activity is +.29 but when the sexes are separated into age groups it is found that the mean physical activity score (3.22) for the older boys (45–57 months) is considerably greater than the mean (2.98) for the younger boys (27–45 months). Although this difference is only 1.8 the standard error of the difference, it is much larger than the difference between the girls' groups of similar age which is only .03. Also the difference in activity between the younger boys and girls is compara-

TABLE 3

Effect of sex and age upon physical activity: Age differences between boys, and age differences between girls in physical activity

SEX	AGE						D	D/σd
	27–45 months			45–57 months				
	N	M	σ	N	M	σ		
Boys......................	7	2.98	.34	10	3.22	.11	.24	1.8
Girls......................	9	2.87	.17	7	2.90	.21	.03	.31

TABLE 4

Effect of sex and age upon physical activity: Differences in physical activity between boys and girls of the same age

AGE	SEX	N	M	σ	SEX	N	M	σ	D	D/σd
months										
27–45	Boys	7	2.98	.34	Girls	9	2.87	.17	.11	.78
45–57	Boys	10	3.22	.11	Girls	7	2.90	.21	.32	3.56

tively slight, but for the older boys and girls it is very well marked, the difference being 3.56 times the standard error of the difference. Therefore it would seem probable that young boys are only slightly more active than girls of the same age, but that they increase in physical activity markedly as they grow older, while girls start on a lower level of activity and do not become more active as their age increases. The results are shown in tabular form in tables 3 and 4.

TALKATIVENESS[7]

Method. In the outset of the study it was hoped that a qualitative as well as a quantitative measure of the children's conversation could be secured. It was found, however, that a one-minute sample did not insure enough acquaintance with the general setting to make this practicable. Moreover, so much of the conversation of the younger children was difficult to understand unless the observer stood so close as to run the risk of interfering with the nursery-school activities, that it was deemed better to abandon the qualitative aspect of the study entirely and to confine attention to the amount of verbal activity without regard to its nature or quality.

Five levels of verbal bahavior or its equivalent were distinguished. Each of these levels was then further divided according to whether the speech or speech-substitute was initiated by the child himself or occurred in response to overt stimulation from a teacher or playmate. The resultant categories were as follows:

[7] This section of the report was done by Ruby Gluckler and Eunice Matheson.

1. O_r—Failure to respond to a definite verbal stimulus, as to a question or request.

2. O_i—Silence when no stimulus was given, i.e., no attempt to initiate conversation.

3. B_r—Bodily response without verbal accompaniment when a definite stimulus is given, as a nod or shake of the head in answer to a question, approaching other person in response to request, etc.

4. B_i—Spontaneous initiation of motion or gesture which clearly is intended as a substitute for the spoken word, as beckoning with hand, etc.

5. V_r—Incomprehensible vocalization or babbling in response to stimulation, as when a child utters an unverbalized "grunt" of objection when another child threatens to encroach upon his place at the sand-pile.

6. V_i—Unverbalized sounds initiated by the child without apparent stimulus.

7. S_r—Single-word responses, including short phrases which are ordinarily learned as units, such as "yes," "all right," "good morning," etc.

8. S_i—Single-word remarks initiated by the child.

9. M_r—Responses involving more than one word. This includes both phrases and sentences, either long or short, also repetitions of single words when joined in a continuous series, as "No, no, no."

10. M_i—Initiation of conversation by the child when groups of more than one word are used.

Reliability of scores. The correlation between the score of the two observers was +.42 which becomes +.59 for the combined series according to

the Spearman-Brown formula. The low reliability is probably a function of the different hours used for observation. The records of Observer G were taken entirely during the lunch hour; those of M during the morning free-play hour. Differences in reaction toward food, in the composition of the groups at the various tables,[8] and similar factors undoubtedly play some part in determining the amount of conversation during lunch. On the other hand, the lunch hour affords the advantages of a relatively fixed situation in which the children are brought face to face with each other in a way which possibly facilitates conversation to a greater extent than do the more variable situations of the free-play hour. It is difficult to say which of the two circumstances affords a better opportunity for securing a valid measurement of talkativeness in general, but the following crude test is at least suggestive.

Two of the items (Nos. 2 and 18) on the Marston scale for introversion-extroversion deal directly with the matter of talkativeness. These items are described as in the tabulation below.

INDICATING EXTROVERSION	INDICATING INTROVERSION
Item 2	
Eager to express himself before a group. Likes to be heard.	Avoids talking before a group. When obliged to talk before a group finds it difficult.

INDICATING EXTROVERSION	INDICATING INTROVERSION
Item 18	
Frank, talkative and sociable, does not stand on ceremony.	Secretive, seclusive, and "shut in," not inclined to talk unless spoken to.

The reliability of the summed ratings on these two items given by 10 observers not including G and M was found to be +.85. When G's observational scores alone were compared with the sum of the ratings of the 10 judges on the two items the correlation was found to be +.71; while M's observations correlated with the summed ratings only to the extent of +.36. Since none of these 10 judges had used the luncheon hour for making their observations of the children, and all except 2 had observed at the same hour as had M, the higher correlation of their ratings with G's scores suggests that the constant situation during the lunch-hour, with the general stimulus to conversation afforded by the face to face position, more than makes up for any possible variant factors such as appetite. An attempt was made to estimate the effect of appetite upon talkativeness at the table by comparing G's scores with ratings on apparent appetite which were given by the teachers in charge of the tables. While only small differences were found, these tended to follow the pattern which might be expected, in that the children with "average" appetites were somewhat more talkative than either those whose appetites seemed to be unusually keen, or those whose appetites were small or who sometimes refused food.

[8] Lunch is served at small tables with a teacher in charge of each. From three to five children sit at each table.

Relationship of talkativeness to other factors. In spite of the low reliability of the talkativeness scores, their relationship to other factors considered in this study is higher than was found for physical activity. The highest correlations are with leadership, where $r = +.61$ (age constant, $+.55$), with extroversion, $r = +.60$ (age constant, $+.62$), and with sociality, $r = +.59$ (age constant $+.53$). With number of days' attendance at the nursery-school there is a suggestion of a curvilinear relationship $\eta_{xy} = +.65$; $\eta_{yx} = +.44$; when corrected for small number of cases and consequent coarse grouping. Inspection of the regression lines suggests that increased length of nursery-school attendance makes for increased talkativeness in the nursery-school situation during the first few months, but that thereafter little further change takes place. It is probable that this is the result of two factors, age and acquaintanceship. Since most of the children enter the nursery-school at about the age of two years, the first few months of attendance would coincide with the period of most rapid development in language ability. Moreover, as the child becomes better adjusted to the nursery-school situation, and more thoroughly acquainted with his playmates he is likely to carry on more conversation with them than while they were comparative strangers. That the factor of acquaintance is more important than that of age is suggested by the fact that little or no corresponding curvilinearity is observed in the regression of talkativeness on age, while the correlation between age and talkativeness is only $+.35$. Correlations between talkativeness and mental age are somewhat higher: $+.49$ for the Minnesota test and $+46$ for the Merrill-Palmer. With I.Q. on the Minnesota test, the correlation is $+32$; with I.Q. on the Merrill-Palmer, $+.35$. With height, the correlation is $+.49$ ($+.39$ with age constant), with weight, $+.29$ (age constant, $+.11$). Talkativeness and beauty correlate to the extent of $+.42$ (age constant, $+.46$); talkativeness and laughter, $+.38$ (age constant $+.27$); talkativeness and attractiveness of personality, $+.38$ (age constant $+.48$). There is a negative correlation of $-.46$ when age is held constant between talkativeness and probability of becoming a behavior problem according to the combined ratings on the Olson scale.

No sex differences in talkativeness

TABLE 5

Differences in talkativeness between children of different occupational classes[9]

	N	MEAN SCORE	σdis	DIFFERENCE	σdiff	Diff/σd
1. Classes I–II..................	11	3.12	0.14	(1–2) 0.14	0.06	2.33
2. Class III.....................	12	2.98	0.17	(2–3) 0.08	0.10	0.80
3. Classes IV–V..................	10	2.90	0.28	(1–3) 0.22	0.10	2.20

[9] Classes I to II include the professional, semi-professional and managerial groups; Class III, clerical, skilled trades and retail business groups, Classes IV to V, semi-skilled, and slightly skilled groups. Group VI, which is made up of day-laborers was not represented in the nursery-school at the time this study was made. See Goodenough (2).

are apparent for this group. Differences between social classes as indicated by paternal occupation are, however, fairly well defined, as shown in table 5.

There is a progressive decrease in the talkativeness scores as we go down the scale of occupational classes. Only 20 per cent of the children in Classes IV to V equal or exceed the median child in Classes I to II in talkativeness. Within this group, talkativeness appears to bear no significant relationship to size of family, position of child among siblings, or to health as indicated either by the hemoglobin test or by the physician's ratings.

COMPLIANCE[10]

Method. The problem of developing objective categories for classifying behavior with regard to compliance or non-compliance proved to be an exceedingly difficult one. Several preliminary scales were tried out for objectivity before one was devised which would meet the requirement of at least 95 per cent agreement among simultaneous observers. Although the final scale showed 97 per cent agreement for 38 cases with from two to four observers for each, other difficulties arose as will be shown later.

The descriptive categories as finally agreed upon were as follows:

1. O—No stimulus, i.e., no request or suggestion made to child during period.
2. A_1—Accepts without hesitation or resistance.
3. A_2—Accepts after brief hesitation and without urging.
4. A_3—Accepts after urging or reminding. Offers no overt resistance.
5. A_4—Accepts after having previously refused. (Verbal resistance.)
6. A_5—Accepts after bodily resistance.
7. A_6—Accepts after both verbal and bodily resistance.
8. R_1—Does not accept. Hesitates, delays or ignores suggestion.
9. R_2—Verbal or vocal resistance. Does not accept.
10. R_3—Bodily resistance. Does not accept.
11. R_4—Both vocal and bodily resistance. Does not accept.

Scores were combined by the method previously described, except that only those cases were used in which there occurred a stimulus to compliance, in the form of a verbal request or suggestion. Since such stimuli were found to occur in only 10.4 per cent of the observational periods, approximately 90 per cent of the observers' time was wasted, so far as getting usable data for this study is concerned. It thus came about that although there were four observers for this part of the study, the combined number of usable records obtained by them was only one-fifth as great as in the studies having only two observers, but in which all the records were significant. A second point of difficulty had to do with arranging the categories in rank-order from most compliant to least compliant. Obviously, in order to secure an adequate measure of compliant or non-compliant behavior in any individual instance a quantitative knowledge of the following factors, and

[10] This portion of the study was made by Frances Jones, Barbara Marx, Robert Challman, and Helen Sundberg.

possibly others as well, should be available: (1) attractiveness of the request or suggestion for the child (2) amount of pressure brought to bear in order to secure compliance. In the absence of such information, a tentative order of arrangement based upon the combined estimates of the entire group of observers was agreed upon as follows: A_1, A_2, R_1, A_3, A_4, R_2, A_5, R_3, A_6, R_4. Data to verify the correctness of this arrangement are wanting.

The following summary shows the relative frequency of the various levels of compliance or non-compliance for this group of cases.

Percentage of time compliance was shown within one minute

Without hesitation or resistance..	42.2
After brief hesitation without urging..........................	11.3
After urging or reminding without resistance......................	4.5
After having previously refused...	1.6
After bodily resistance...........	1.5
After bodily and verbal resistance.	0.5
Total compliance within one minute..........................	63.2

Percentage of non-compliance

Hesitates, delays or ignores......	15.9
Verbal or vocal resistance........	12.4
Bodily resistance.................	4.9
Both vocal and bodily resistance..	5.0
Total non-compliance............	37.8

Percentage of time bodily resistance was shown

Bodily resistance.................	6.4
Bodily resistance accompanied by verbal resistance................	5.5
Total bodily resistance...........	11.9

From these tables it can be seen that immediate compliance occurs in 4 out of 10 requests, and that in roughly 60 per cent of the cases, the nursery-school children comply with requests within one minute. These requests are not only from the teachers, however, but also from the other children, a fact that might lead one to expect even a higher percentage, if suggestions were proffered by adults only. It can be seen also that these children offer some degree of bodily resistance in a little better than 10 per cent of all instances.

Reliability of scores. The average intercorrelation between the 4 observers was +.18, which becomes +.47 when corrected by the Spearman-Brown formula. The low reliability may fairly be attributed to the small number of effective observations, rather than to greater inaccuracy in classification or to greater inconsistency in the children's behavior than was present for the other traits studied. Had a request or suggestion been made to *each child in each observational period* so that all the observations could have been used, the expected reliability according to the prophecy formula would have been +.90 for 4 observers or +.82 for 2 observers. It is evident that the ordinary nursery-school routine does not provide adequate opportunity for the observation of behavior of this kind except at the cost of a considerable expenditure of time. Possibly a formal laboratory test might serve the purpose better, although it should be noted that in the study carried out by Reynolds (6) in which the test-method was employed the obtained reliability was only +.46.

Relationship of compliance to other factors. All the intercorrelations are so low that little reliance can be placed upon them. If we should adopt the very lenient viewpoint that correla-

tions between .2 and .4, which, with the number of cases involved, means roughly from two to four times the probable error may possibly suggest trends, we find some indication of a small positive relationship between compliance and the following traits: sociality, leadership, and beauty; and of a small negative relationship with laughter, physical activity, talkativeness, extroversion, chronological age, mental age on both the Minnesota and the Merrill-Palmer tests, and length of nursery-school attendance.

LAUGHTER[11]

Method. The general procedure was the same as that outlined under the foregoing studies. There were 3 observers, 2 of whom made their observations during the free-play hour in the morning while those of the third were divided between the afternoon free-play hour and the morning hour devoted to stories and rhythms. Eight descriptive categories were used for recording the behavior, but because of the very small number of frequencies falling under the first three heads, these were later combined in the statistical treatment. The categories with their definitions follow:

C—Crying. Audible crying accompanied by tears.

W—Whimpering. A low broken whining, not accompanied by tears.

P—Pouting or frowning. A protrusion of the lips in ill-humor; a knitting of the brow in displeasure.

So—Sober. A calm unemotional expression, whether talking or not.

[11] The study of laughter was made by Josephine Conger, Cornelia Taylor and Ruby Friend.

Sm—Smiling. A pleased or amused expression, characterized by a lateral upward extension of the lips.

L_1—Brief laughter. Not more than two spasmodic expulsions of breath with jerky sounds accompanied by movement of the facial muscles.

L_2—Prolonged laughter. More than two spasmodic expulsions of breath as above described.

L_3—Shouting laughter. Loud and boisterous laughter.

Reliability of scores. The correlation between the scores of the 2 obseovers who made their records at the same hour of the day was +.77; while the correlations between their scores and those of the third observer were +.61, and +.47 respectively. Again, the differential effect of a change in the situation upon the behavior of individual children is evidenced. The average intercorrelation for the 3 observers is +.61, which becomes +.83 when corrected by the Spearman-Brown prophecy formula.

Relationship of laughter to other factors. Perhaps the most interesting result obtained from a study of the table of intercorrelations with frequency of laughter is to be found in a group of curvilinear relationships which, taken collectively, afford some evidence that the optimum position with respect to laughter lies at about the mid-point of the distribution rather than at either extreme. These may be summarized as follows: The children who laugh an average amount tend to exceed those whose laughter is either excessive or deficient (in comparison with the remainder of the group) in sociality (η_{xy} = +.34, η_{yx} = .52); they are somewhat less likely to be

regarded as behavior problems, (η_{xy} = .43, η_{yx} = .57); and are slightly more compliant to the wishes of others, (η_{xy} = .36, η_{yx} = .27). All these correlations have been corrected for coarse grouping due to the small number of cases. Little or no tendency toward curvilinearity is, however, apparent in the correlation between laughter and leadership, where r = +.53, age constant, +.33; or with talkativeness, r = +.38; age constant, +.27; beauty, +.34, age constant, 40; attractiveness of personality, r = +.35, age constant, +.48; extroversion, r = +.38, age constant, +40; chronological age, r = +.45; and length of nursery-school attendance, r = +.48, age constant, +.26. With age constant, the correlations between laughter and intelligence as measured either by the Minnesota or the Merrill-Palmer test, between laughter and height, weight, and health ratings were all less than twice the probable error. Likewise, no sex differences and no differences associated either with size of family, position among siblings or paternal occupation were apparent in this group.

SOCIAL TRAITS[12]

Method. The observers for this study endeavored to distinguish between and to make separate records of two aspects of social behavior, a quantitative aspect which may be labelled "social participation," and a qualitative aspect denoting various levels of leadership. The results, however, show such a high degree of correlation between the two series of scores as to render it evident that either social participation and leadership are fundamentally similar, or that the descriptive categories have failed to make adequate distinction between them. It is believed that the second hypothesis is at least partially true, and furthermore that the fault lies with the definitions used for the so-called "leadership" series rather than with those used for social participation. If this is correct, the findings for social participation are the more significant. However, the results from both series will be reported.

The categories used, with their definitions, are as follows:

I. For social participation:

A. Solitary unoccupied. A child who is not in close proximity with any group and is not in conversation with any other child. Doing nothing.

B. Solitary occupied. A child who plays by himself. There is no conversation with other children, and he pays no attention to other children.

C. Parallel activity. This is the simplest type of group formation. Each child is in close proximity with other members of group, and all are engaged in the same or similar occupations, with or without an occasional observation from one member of the group to another but there is *no* conserva-

[12] Bertha B. Hayes and Jean Wilcox were the observers in this study and are authors of this section.

tion between members of the group. Each individual child's activity is a unit.

D. Simple coöperative activity. The members of the group are engaged in the same or allied occupations and there is conversation between members of the group. Each child's activity may be modified by others in the group through observation and imitation, and yet each child's activity is a unit. There may be taking of turns.

E. Organized coöperative activity. There is an assignment and differentiation of parts among members of the group. Each child contributes his or her part to the activity of the group, and here the group rather than the individual child is the unit.

II. For leadership:

1. Interfered with. The child who is or is not engaged in some activity has been interfered with by one or more children.
2. Interferer. The child who initiates an interference with a single child or with a group of children. This is not classed as an occupation in itself.
3. Rebel. The child is rebelling against the interference or coercion of one or more children but does not initiate the interference or coercion himself.
4. Observer. A child whose interest is in the group as shown objectively by observation and who is in close proximity with the group but is not a participant.
5. Participant. One who is participating actively with the group, or who is a follower or imitator in the group activity.
6. Unsuccessful leader. A child who is opposed in an attempted coercion by one or more members of the group.
7. Successful leader through force or trickery. A child who dominates other children of the group against their will.
8. Successful leader through persuasion or personality. The child who is being imitated in his activity or who is able to persuade other children to follow him or to control their activities.

Reliability of the scores. For both sociality and leadership the correlation between the scores of the 2 observers was +.61, which becomes +.76 when corrected by the Spearman-Brown formula. The correlation between the combined scores of the 2 observers on sociality and leadership is +.98; with age constant, +.96. The fact that the correlation between the two supposedly dissimilar traits is so much

higher than the reliability of either can hardly be explained on any other basis than that the 2 series of records really measured the same thing to a very great extent. Since both records were made on the same occasions, the day-to-day fluctuations of behavior which have operated to lower the reliability coefficients would not appreciably affect the correlations between the two traits.

Relationship between social traits and other factors. Correlations with the other observational scores have already been mentioned. When age is held constant, the correlation between sociality and extroversion is +.60; between leadership and extroversion is +.59. Correlations with chronological age are +.74 for sociality and +.71 for leadership. Attractiveness of personality correlates with sociality to the extent of +.34 and with leadership, +.43, when age is held constant. The corresponding figures for height are +.31 with sociality and +.29 with leadership; with the Olson behavior problem scale, −.18 for sociality and −.32 for leadership. The correlations with weight, I.Q. on each of the two tests used, nursery-school attendance, and health ratings are all less than twice their probable errors. No reliable differences associated with sex, occupational class, size of family or position among siblings were established.

RATINGS SCALES AND INTELLIGENCE TESTS

Discussion of results

Ratings scales. The 4 series of ratings were described briefly in the introductory section. The reliability of the combined ratings of the 12 judges[13] for each scale was computed by correlating the summed ratings of one-half of the group against those of the other half and correcting by the Spearman-Brown formula. The reliability coefficients obtained in this way were as follows: for the Marston introversion-extroversion scale, +.98; for the Olson scale for the prediction of behavior problems, +.94; for the ratings on attractiveness of personality, +.95; and for the beauty rankings, +.91. The average intercorrelations of the various judges on the separate traits is in the neighborhood of +.60.

The reliability of the combined ratings is very high for all four traits. This is due to the large number of judges, and to the amount of time spent by each in observing the children immediately preceding the time of making the ratings. It should also be noted that all except one or two of the judges had had extensive acquaintance with young children previous to the time of making this study and that several of them were acting as part-time assistants in the nursery-school or were using the children as subjects in their own thesis problems. It is probable, moreover, that the method of taking the observational samples has in some measure contributed to accuracy of ratings, in that it insures an equal division of time among all the children observed, rather than too great a concentration of attention upon a few outstanding cases.

Inter-correlations between these rat-

[13] Thirteen students participated in making the observations, but only 12 were present when the ratings were made.

ings are in general not high. On a priori grounds one might expect that many judges would fail to discriminate between beauty and attractiveness of personality, but as the correlation between the two series is only +.08, this seems not to have been the case. Beauty correlated with extroversion to the extent of +.36 and has a negative correlation of −.58 with likelihood of becoming a behavior problem according to the Olson scale, when age is held constant. With the Minnesota I.Q. the correlation is +.29; with the Merrill-Palmer I.Q. the correlation is +.43. Other correlations with beauty are negligible. Attractiveness of personality shows a positive correlation (age constant), of +.42 with extroversion and a negative correlation of −.80 with the Olson ratings. Negative correlations of −.32 and −.28 are also found between the Olson scores and I.Q.'s on the Minnesota and Merrill-Palmer tests.

Of the two intelligence tests, the Minnesota shows a correlation of .78 and the Merrill-Palmer of +.85 between mental and chronological ages. The Minnesota I.Q.'s have a zero correlation with chronological age; the Merrill-Palmer a small positive correlation (+.24). The correlation between the two series' of mental ages is +.90; between the I.Q.'s the correlation is +.67. The correlation between length of nursery-school attendance and Minnesota I.Q. is +.30; between length of nursery-school attendance and Merrill-Palmer I.Q., +.46.

DISCUSSION OF RESULTS

The method of short samples has shown itself to be a useful means of studying the spontaneous behavior of young children in the nursery-school. With continued use of the method, a number of problems have, however, arisen for the solution of which further evidence is needed. It is apparent from the data presented in these studies that in order to secure maximum reliability in the usual statistical sense of the term, observations should always be taken at approximately the same time of day and under similar conditions. Is there a likelihood that this increased reliability may be gained at the expense of a loss in validity; i.e., in the amount of confidence which may be placed in the obtained scores as an index to the child's most typical behabior with regard to the trait in question? The foregoing studies have shown rather clearly that a change of situation does not affect all children in a precisely similar manner. On a priori grounds, therefore, it appears that a truly valid measure of behavior must be based upon observations taken under such a diversity of circumstances as to constitute a representative sampling of the child's daily life. Since in practice this is rarely feasible, the problem resolves itself into a question of determining how many and what kinds of situations should be sampled in order to secure, within a given total amount of time, the most adequate picture of the child's habitual reactions. Unless the observational time is unlimited, the question cannot be answered by an equi-proportional division of the child's daily program, since some situations may provide so few opportunities for the display of a given form of behavior that the greater part of the observer's time is wasted. The study

of compliance is an illustration of the loss in reliability resulting from infrequent environmental stimulation for the display of the trait. It is probable that this factor is largely responsible for the superiority of the lunch-hour over the free-play-hour for the observation of talkativeness. In general it seems to be true that, all other things being equal, the situations which tend to call forth the maximum display of a given form of behavior for the majority of the subjects may be regarded as optimum for securing a reliable series of observations on such behavior. While our data do not permit wide generalization, the fact that talkativeness scores for the lunch-hour were found to correlate more highly with the subjective estimates of 10 independent judges than did scores made during the free-play hour, in spite of the fact that none of the judges had made systematic observations of the children during the lunch-hour is significant. It suggests that the use of a single type of situation for the observation of behavior may not affect the validity of the observational scores to as great an extent as might be supposed, provided that the situation be wisely selected.

A second question of practical import has to do with the optimum length of the single observational sample. Given a certain total amount of time to spend in observation, how may that time most effectively be divided? Here also it seems probable that the answer will differ according to the trait to be observed. For certain very overt and simple modes of behavior, such as physical activity, a glance is sufficient to ascertain what is occurring at any given instant. In these cases our experience has led us to believe that a shorter time-sample—possibly even as short as fifteen seconds—may perhaps yield more reliable data than can be secured by dividing the time into fewer and longer periods. For more complex forms of behavior such as leadership, a longer period is required in order to classify a single event with accuracy. A special study on the optimum length of the time-sample for various characteristic aspects of behavior is planned for the near future.

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The Mental Organization of the Newborn

Paul Hanly Furfey, Martha Anne Bonham, and Mae Kathryn Sargent[1]

Gesell (1) has shown that something analogous to "general intelligence" exists in young infants. The child who is retarded at the age of six months will probably be proportionately retarded at one year. Linfert and Hierholzer (2) have demonstrated the possibility of constructing a statistically valid scale for measuring mental development in the first year. They showed that even at one month there is a general factor underlying the child's responses—a factor apparently similar to the "general intelligence" of the educational psychologist.

The present authors were interested in determining when this general factor makes its appearance. Is it present at birth or is it acquired during the rapid growth which characterizes the first postnatal month? To answer this question a scale of tests was devised and administered to 66 infants in the maternity ward of Providence Hospital, Washington, D. C. Four of these infants were excluded from the final study on account of incomplete data. The remaining 62 subjects ranged in age from 15 minutes to 343 hours with a mean age of 91.73 hours.

The final scale consisted of 17 items; namely, plantar reflex, right and left, leg withdrawal reflex, right and left, hand and foot, reaction to light, convergence of eyes, following moving object with eyes, sucking reflex when a nipple was presented, and reaction to bell, clang, and whistle. The authors were interested in the quantitative measurement of those reflexes rather than in their qualitative descriptions. It was not the purpose of the present investigation, for example, to consider

TABLE 1

Reliabilities of tests for infant reflexes

		Reliability
1	Plantar—left	.761
2	Plantar—right	.581
3	Withdrawal of leg—left	.652
4	Withdrawal of leg—right	.733
5	Grasping—left foot	.902
6	Grasping—right foot	.906
7	Patellar—left	.668
8	Patellar—right	.739
9	Grasping—left hand	.749
10	Grasping—right hand	.857
11	Eyes close at light	.568
12	Eyes converge	.784
13	Eyes follow moving object	.945
14	Lip reflex	.901
15	Reacts to bell	.879
16	Reacts to clang	.799
17	Reacts to whistle	850
	Mean	.781

[1] P. H. F. was responsible for planning this investigation and for the statistical analysis. M. A. B. and M. K. S. did the actual testing.

TABLE 2

Intercorrelations of infant reflexes

	PLANTAR REFLEX	LEG REFLEX	GRASPING (FOOT)	PATELLAR	GRASPING (HAND)	LIGHT REFLEX	CONVERGENCE, EYES	MOVING OBJECT	LIP REFLEX	BELL	CLANG	WHISTLE
Plantar reflex	×	+.448	+.072	−.053	−.356	+.130	−.105	−.125	−.386	−.105	−.232	−.292
Leg reflex	+.448	×	+.107	−.107	−.128	−.142	−.195	−.224	−.072	−.094	−.190	+.288
Grasping (foot)	+.072	+.107	×	+.021	+.168	+.076	+.379	+.232	+.192	−.018	−.206	−.029
Patellar	−.053	−.107	+.021	×	+.112	−.173	−.093	−.064	−.073	+.332	+.117	+.242
Grasping (hand)	−.356	−.128	+.168	+.112	×	−.473	+.017	−.206	+.875	+.292	−.124	+.581
Light reflex	+.130	−.142	+.076	−.173	−.473	×	+.148	+.045	−.031	−.150	−.253	−.167
Convergence, eyes	−.105	−.195	+.379	−.093	+.017	+.148	×	+.675	+.242	+.008	−.059	+.037
Moving object	−.125	−.224	+.232	−.064	−.206	+.045	+.675	×	+.028	+.455	−.082	+.849
Lip reflex	−.386	−.072	+.192	−.073	+.875	−.031	+.242	+.028	×	−.062	−.211	−.274
Bell	−.105	−.094	−.018	+.332	+.292	−.150	+.008	+.455	−.062	×	+.317	+.534
Clang	−.232	−.190	−.206	+.117	−.124	−.243	−.059	−.082	−.211	+.317	×	+.441
Whistle	−.292	+.288	−.029	+.242	+.581	−.167	+.037	+.849	−.274	+.534	+.441	×

Probable errors vary between .020 and .086.

whether the infant's plantar reflex consisted in flexion or extension. The point was rather whether the reflex was slow and slight or quick and ample.

It was found impracticable to measure the activity of these reflexes by any physical measuring device available to the present investigators. It was therefore decided to use a graphic rating scale on which 2 judges could express their judgments independently. These judgments were correlated and reliabilities of the combined judgments were estimated by the Spearman-Brown formula. The results are shown in table 1. It will be seen that the ratings show a satisfactory reliability for statistical purposes.

The next step was to study the intercorrelation of the various responses. Before doing this the ratings on similar reflexes involving the two sides of the body were combined. That is, right and left plantar reflexes were combined into a single score, right and left patellar reflexes, and so on. It was felt that this procedure was justified because there were few cases in which the corresponding right and left reflexes were not equally active.

The intercorrelations are shown in table 2. If there is a general factor underlying the infant's various responses then the average intercorrelation should be significantly different from zero. The average correlation, however, was found to be .044. This does not seem significant.

A closer analysis of the table reveals certain interesting facts. If intercorrelations affecting one part of the body are considered, the correlation becomes much higher. In the upper left-hand corner of table 2 a square has been drawn around the intercorrelations of a number of reflexes involving the lumbar cord. The mean intercorrelation within this group is .081. Similarly, if a square be drawn about the coefficient of responses involving the cranial nerves—light reflex, convergence of eyes, response to a moving object, and lip reflex—it will be found that the average coefficient within the square is .184. In the lower right-hand corner is a square drawn about the intercorrelations involving the cranial nerves and body musculature. Here the mean correlation is .431.

It may be inferred that the average of all the coefficients in the table, .044, is as high as it is, on account of the coefficient within the squares. This inference is correct. The average of the coefficients in the table which are outside the three squares is .0005—exactly zero for statistical purposes.

These results make possible a tentative answer to the original question. No general factor is discoverable in the mental life of the newborn infant. There are only specific groups of abilities involving specific parts of the nervous system. The infant at birth is not a mental unit. It seems reasonable to suppose that it is the maturation of the nerve tracts which welds these discrete elements into the integrated mental whole discoverable at the age of one month.

SUMMARY

1. A scale involving 17 responses was given to 62 newborn infants.

2. The intercorrelation of the results of these tests proved to be zero after certain intercorrelations involving specific parts of the nervous system had been eliminated.

3. These results suggest that there is no mental integration in the newborn. Integration takes place during the first postnatal month and can be reasonably supposed to be conditioned by the maturation of the nerve tracts.

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The Heilbronner Test for Preschool Children

Roberta S. White

The original Heilbronner test was designed to measure "apperception" or imagination (1). It consists of 12 series of line drawings printed on small cards and representing familiar objects. There are from 3 to 7 cards in each series. On the first card of a series only one or two lines of the picture are shown. In each succeeding card more lines are added until in the final card the picture is completed. These cards are shown to a subject one at a time in the given order and he is instructed to name the object depicted. The more quickly he grasps the meaning of a picture even though some details are lacking, the more proficient he is in the test.

The following study was made with the purpose of seeing whether this test might be of use with preschool children. It was first given in its original form to a preliminary group of 16 children in the Child Institute at the Johns Hopkins University. From the results thus obtained the test was greatly shortened by the elimination of those pictures and series of pictures which were of no value in differentiating levels of ability among the children. This revised form was then given to 31 children at the Institute of Child Welfare at the University of Minnesota and the results studied in the light of chronological and mental age.

PRELIMINARY TEST

The group of 16 children used in the preliminary test ranged in age from 3:0 to 5:4 years with the median at 4:3 years. There were 10 boys and 6 girls. The procedure was as follows. The child was seated in a small chair at a low table. His attention was directed to the table by the experimenter (E) pointing and saying, "I am going to show you some pictures right here." Then the first picture was placed on the table in front of the child while E said, "Tell me what that is." If the response was wrong E said "No," and showed the next of the series, saying "What is that?" This phrase was repeated at the beginning of each new series and whenever the child hesitated too long. When the response was right E said, "That's right," and then showed the rest of the series. At the end of the first series E explained that the pictures were all of the same thing only the first one had just a few lines and the rest had more and more until the picture was finished.

The pictures were shown in the alphabetical order of the letters A to N which designate them. (The letters J and K were omitted from the original test.) A record was kept of every response and of the general attitude of

the child. Leniency was used in counting responses correct, for instance "tick-tock" was accepted for clock, and radio for phonograph, since few children have seen the old fashioned type of phonograph depicted, and it looks much like a radio.

METHOD OF REVISION

The results from this preliminary test showed clearly that a revision was needed if the test were to be useful with preschool children. Table 1 gives these results. It tells the number in the series of the card or drawing which elicited the correct response in that series for each child. These series of drawings represented by letters are arranged in order of difficulty as measured by the number of children which named them correctly. The subjects are arranged in order of age from oldest to youngest. A dash signifies the child was unable to name even the last card of the series.

It appears that the 3 most difficult series, the thermometer, phonograph, and fountain pen, were practically useless since so few of the children were familiar with the object depicted. These were discarded in the revision of the test. The pencil and broom series were also eliminated because of the similarity among the cards comprising each series. The windmill was of the Dutch type which children meet only in pictures, so it too was discarded.

The 6 remaining series were then shortened by eliminating those cards which had little value, that is which in few or no cases elicited the first correct response of the series. As finally revised the test included series with cards as follows:

TABLE 1

Number of card in the series eliciting the first correct response; preliminary test—original Heilbronner

SERIES	SUBJECT															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I. Thermometer	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
E. Phonograph	—	3	—	—	—	6	5	—	—	—	—	—	6	6	—	—
N. Fountain pen	—	—	—	1	—	—	1	—	3	3	—	—	—	2	—	—
G. Butterfly	3	6	6	6	5	6	—	6	6	—	—	—	—	3	—	—
A. Windmill	1	5	—	6	6	6	—	1	4	1	—	—	4	—	6	—
F. Book	4	1	4	3	4	4	4	3	2	4	—	—	4	2	—	4
H. Broom	4	4	—	1	1	1	4	1	1	1	1	—	1	1	—	1
B. Lamp	3	1	1	1	1	1	—	1	1	1	—	1	2	1	—	3
L. Bicycle	5	4	—	—	5	4	5	4	4	6	4	4	5	5	4	5
D. Pencil	2	1	4	1	1	4	4	4	2	1	1	—	5	1	—	1
C. Telephone	2	7	6	6	6	4	3	6	6	6	4	7	6	3	7	7
M. Clock	2	2	2	3	3	2	3	2	3	3	3	3	3	3	3	3

Clock:	2 cards, Original order in series 2 and 3
Book:	2 cards, Original order in series 2 and 4
Lamp:	2 cards, Original order in series 1 and 3
Bicycle:	2 cards, Original order in series 3 and 5

Butterfly: 3 cards, Original order in series 3, 5 and 6
Telephone: 4 cards, Original order in series 2, 4, 6 and 7

RESULTS WITH THE REVISED FORM

Thirty-one children were given the revised form, 17 of whom were boys and 14 girls. Their ages ranged from 2:2 to 7:5. I.Q. averaged 108.6 with a range from 85 to 152. The I.Q. was taken from previous tests, Kuhlman-Binet for 13 of the older children and the unpublished Minnesota test for 18 of the younger.

The procedure was identical with that of the preliminary test except that the method of exposing the cards was more standardized. Instead of merely placing them on the table in front of the child they were shown one at a time through an opening 2½ inches square in a large envelope of black paper which was tacked to the table top. Each card was glued to a strip of black paper which served as a handle to remove it, thus exposing the next card in the series. Lighting was from the left and above.

Scoring followed the method used by Clara H. Town (2). One point was given for each picture correctly named, so 15 was the maximum score obtainable. Leniency was again used. Thus "lantern" and "light" were accepted for the lamp, and "tricycle" and "kiddie car" for the bicycle.

The scores ranged from 0 with the youngest child to 13 for one of the oldest, and averaged 7.5 points. The girls show a superior score even though their average age is less than that of the boys. This is probably explained by the higher I.Q. of the girls.

	Boys	*Girls*
Age	3:8	3:7
M.A.	3:11	4:1
I.Q.	104.4	113.8
Score	6.8	8.4

TABLE 2

Number of card in the series eliciting the first correct response—revised Heilbronner

SERIES	SUBJECT																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Clock	1	1	1	2	2	2	1	2	2	1	1	1	1	2	2	1	1	1	1	1	1	1	1	—	1	2	1	—	—	1	—
Book	1	1	1	1	1	1	1	1	2	1	1	—	1	1	1	1	—	—	1	1	1	—	1	—	1	—	—	—	1	1	—
Lamp	2	2	2	2	2	1	2	2	2	2	2	2	2	—	2	—	—	—	2	2	2	—	—	2	1	—	—	—	2	2	—
Bicycle	2	2	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	2	2	1	2	1	—	2	—	1	—	1	1	2	—
Butterfly	1	3	3	3	2	—	3	1	3	—	—	1	—	—	—	—	—	—	0	—	1	—	—	—	—	—	—	—	—	—	—
Telephone	3	3	3	3	2	2	2	3	2	—	2	3	3	—	2	2	4	4	2	2	2	2	2	3	4	—	2	1	2	2	—

Correlation between C.A. and score was .83±.04, between M.A. and score .74±.06. No significant correlation was found between score and I.Q.

Table 2 shows that every card of the 6 series was useful in eliciting the first correct response of a series from at least one child. The first card in the "book" series was recognized as a book by 21 children yet 9 failed to get it correct on the last card. The "butterfly" was too difficult for two-thirds of the children or else unfamiliar to them. Pictures of other objects more usual in a child's world could be included advantageously in the test.

The use of this test with children

under $3\frac{1}{2}$ years may be critized on the grounds of the language element. Scoring is difficult when the child's enunciation is poor. The young child has a tendency to repeat the same syllable over and over again whether it has any connection or not. Furthermore the test lacks manipulation, which is often necessary to hold a child's attention. But with older children of the preschool age the test might be of definite value in measuring "imagination," or better still as one of a series of tests for that purpose.

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Variations in the Responses of Infants During First Ten Days of Post-natal Life

EDITH S. BRYAN

THE problem of the present research is the consideration of those factors present at birth and in the earliest days of the new-born infant's life which may lend their influence to the determination of his reactions and behavior. Such a study presupposes careful observation of the various stimuli which affect the child and also consideration of all activities which are the resulting effect of known or unknown stimuli. This study[1] includes careful note of the condition of the mother during pregnancy and observation of the type and length of labor and delivery, together with the reactions of the infant on each of the first ten days of life, to certain constant stimuli presented under conditions as nearly identical as can be set up with the new-born child. Attention was given to the cry, the reactions to light and sound, grapsing and the Babinski reflex and to various types of muscular activity. Aside from this stenotyped work of an experimental nature careful note was made of any unusual activity or condition produced by an unknown stimulus.

In order to make the study as complete and exhaustive as possible the investigator studied the physical and other conditions of the mother prior to labor, attended the mother during labor, observed the reaction of the child on delivery and for some time succeeding delivery, and made examinations concerning the reactions of the child to its accustomed environment. Definite stimuli were given under experimental conditions twice each day for a period of ten days. The tests were made both during the waking and during the sleeping periods of the child. The waking period was taken immediately succeeding the bath which just preceded a nursing period, both factors being considered as lending aid to determining the most wide awake period of the day. The sleeping period was chosen as that immediately succeeding the nursing period when the child seems to have fallen into the soundest slumber. The number of mothers examined were 64 and the

[1] This investigation was made at the Psychological Laboratory, The Johns Hopkins University. The mothers and infants studied were in the maternity ward of the University of Maryland. To the data obtained for the Baltimore infants were added similar data for Mexican children and for some negro children in California. To the members of the staff of each hospital coöperating in the study the author acknowledges gratitude for the opportunity given to her and for their active and helpful coöperation in securing records. The continuation of the study by the author is in progress at the University of California.

number of infants from these mothers was 66, as 2 pairs of twins occurred in this group. For certain reactions additional infants were observed as in the case of the Babinski reflex when 100 infants were tested.

REACTIONS TO LIGHT

In this study it has been observed that following the normal and not too difficult birth of a vigorous child the infant generally remains awake for the first two hours or more after birth, and that during this period the child has a tendency to lie with wide open eyes and eyeballs rolling about with a fair amount of coördination. Careful note was made of all who opened the eyes immediately after birth and 15 of the 66 opened the eyes at once, either prior to other muscular activity or simultaneously with it.

In one hospital the practice was to administer the drops of silver nitrate as soon as the cord was tied and cut; and as this was completed within the first two or three minutes the eyelids were retracted and the drops administered before the infant had voluntarily opened the eyes. It gave the appearance that this practice delayed the normal opening of the eyes somewhat, as in a second institution the administering of the drops was delayed until the baby was removed to the nursery. The percentage of infants, in this second group who opened the eyes immediately was somewhat larger than in the first group. The average delay was not more than fifteen minutes, however, in the first group.

In the study of the effect of light stimuli the following materials were used: for the first three days the stimulus was the Winchester Flashlight No. 5911, charged with No. 935 Ever-ready Unit Cell; for the succeeding days the light used was the French Ray O Lite charged with Ever-ready Unit Cells No. 950. The latter light was focused to a point at 1 foot but used 3 feet from the child for the fourth and fifth day and thereafter focused for 3 feet and flashed at that distance.

The light was flashed on the face of the child three times during each experimental trial. Two such trials were made daily, one during the sleeping period and one trial during the period when the child was awake. The newborn gives a much more acute reaction to a sudden light thrown on the face during the first three of the neo natal days than it does during the succeeding seven days. This fact holds whether the child is asleep or awake. *It was repeatedly observed that, during* the first three days of life, when a light falls on the eyes the child frequently gives a start, the lids are more tightly closed, a frown appears, the lips also are frequently closed more firmly and if the light persists the head is moved from side to side, is thrown back or turned well away from the source of light. The reaction to the light is more extreme when the child is asleep than when it is awake, as during the waking periods the reaction consists of a quick blinking of the eyes accompanied frequently with a downward movement of the head and a frown less severe than when asleep.

After the first three days are passed, as a rule, these reactions become notably less severe, until by the fifth to seventh day the reaction is very mild and generally wholly disappears before

the tenth day so that a light flashed in the face of a sleeping child brings no reaction whatsoever. When the stronger light is flashed in the eyes of a child that is awake, there will frequently be one blinking movement and then the eyes will open wide while the child gives the appearance of looking directly at the light or alternately looking at it and away without paying any attention to the presence of the light and without further blinking. The reaction seen during the first three days seems much like that described by Preyer (8) as occurring from the tenth day on. The fact that the reaction was not generally seen after the fifth to seventh day in the present experimental study may be due to adaptation of the organism to the stimulus, after the application of the stimulus for from three to five successive days.

At no time was any of this group observed to follow the light or other bright object during this ten-day period of observation. The investigator was always dressed in white when with the mothers and infants and several times an infant had the appearance of fixating the investigator's face or white dress but it was probably the brightness or whiteness that attracted the attention and held it momentarily. One such instance was caught in a picture. Further description of this incident is given under the section on muscular activity.

Conclusion

The eyes of the vigorous new-born infant have a tendency to open voluntarily as one of the earliest muscular activities and the eye-balls roll from side to side.

The eyes of the new-born infant soon adapt to light. The reaction to a light flashed in the face is more severe when the child is asleep than when awake. The adaptation generally occurs within the first five days and what reaction is seen after that time is of a very mild nature.

The average infant does not follow a light or point of brightness with its eyes during the first ten days of its life.

Occasionally an infant, in the first ten days of life, will fixate a light or bright or white surface for a notable period of time.

HEARING

The subject of hearing in infants has been much discussed by observers and experimenters in child psychology. It was formerly rather universally thought that a new-born child was wholly deaf. There has been a variety of opinions expressed as to when the hearing was attained and opinions varied from the idea that it was gained a few hours after birth to the belief that the sense of hearing was not present for days. Those who believe the child to be deaf after birth are Preyer (8), Tracy (12), and Rasmussen, while Miss Shinn (10) possibly holds this view as she reports, "The baby showed no signs of hearing anything until the third day." An opinion quite opposed to this is held by Tanner (11), and Watson (13), who contend that the infant hears the first day, although even these writers seem to admit that the sense of hearing does not develop alike in all infants.

In this study three forms of auditory stimulation were used.

For the deeper tones a little hand

bell was used which had a salient pitch of approximately 512 vibrations frequency, one octave above middle C. The procedure tried first with each infant was to hold the bell sidewise and lifting the clapper to the upper side let it fall to the lower. The fall of the clapper was through a distance of 2 inches. The bell was within 1½ inches of the ear.

The second procedure was to ring the bell sharply as close to the ear as possible without touching the child.

The third procedure was with the use of the Galton (Edelmann) whistle which was sounded within 1 inch distance from the ear at pitches of ten, fifteen, twenty, twenty-five and thirty-five thousand vibrations and each pitch sounded three times with an interval of silence between. Each of these procedures was followed twice each day for the ten days, once each during both the waking and sleeping period, the periods being the same as those described in the preceding experiments. Each sound was given three times.

The result of the first procedure was absolutely negative. To the sound of the bell elicited by the fall of the clapper through the distance of 2 inches (the diameter of the bell rim), there was no reaction that was distinguishable with any child at any time, sleeping or waking, during the ten days of trials.

The result of the second procedure, the sharp ringing of the bell, appeared positive although some doubt might occur to the minds of certain investigators as to the validity of the interpretation. It is well known to those whose daily life is spent with the newborn that an infant is frequently seen to give a sudden violent start, similar in appearance to the strong muscular start given by an adult just dropping asleep. This sudden start of the infant has repeatedly been observed by the investigator in the absence of any dis-

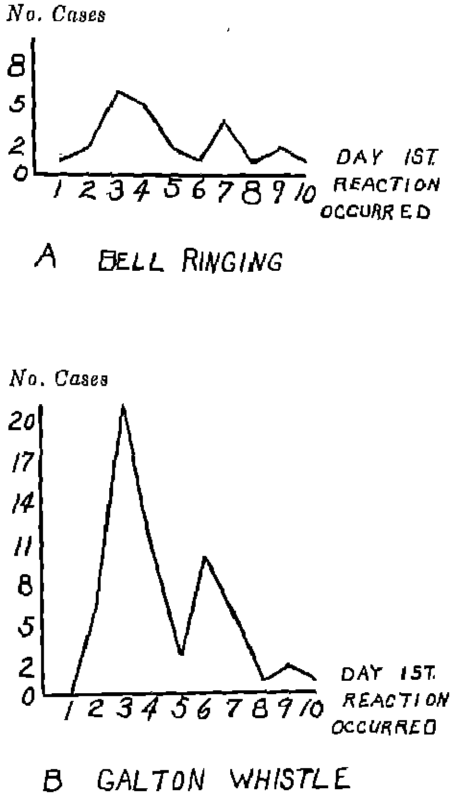

FIG. 1. REACTION TO SOUND

cernable external stimuli. In one hospital where the nursery was five stories up on the quiet side of the hospital grounds and well isolated by corridors from any noisy portions of the house within, this phenomenon was frequently seen and in practically all of the infants. The conception of the cause as that of

jar seemed equally untenable as the building was of brick and concrete and no trains passed near. Unless these little organisms are as delicate as the seismograph they could not be considered as registering jar in this way. Bearing in mind this start from an unknown cause it is difficult to determine just when a stirring is due to the stimulus of sound and when it is due to this unknown factor mentioned above. The reaction of the sound of the ringing bell most frequently apparent was that of stirring or turning toward the sound. The reaction of blinking was that next in frequency while a severe start or a cry were more rarely observed.

This second experiment of sound was only tested on 31 cases. In 2 of these no reaction was observed in the 20 trials given (2 on each of ten days). In 4 other cases a seeming reaction was observed only once with each child, so that these cases were eliminated as possibly belonging to the type of case cited above where the cause for the start is unknown. The occurrence of the time of the first reaction is shown in figure 1. This indicates the first reaction to sound as being first observed for 17 out of 25 cases between the third and seventh day, 3 occurring prior to that time and 4 being seen later.

The reaction, if such it could be considered, appeared very erratic, after what seemed to be a definite reaction to a given stimulus several days might elapse before any further reaction was seen. In no case was a reaction seen to appear each day succeeding the first appearance. The reactions noted were of six different types, arranged in ascending order of frequency: opening of eyes, crying, starting (rather violent), blinking, turning toward the sound and simple stirring. In all these tests made on all the infants the reactions were seen the following number of times:

Reaction	*Number of occurrences*
Opening of the eye	5
Crying	6
Starting (violent)	15
Blinking	17
Turning toward sound	18
Stirring	45

With the Galton whistle (Edelmann) the findings were somewhat similar to those resulting from the bell ringing. A reaction to the sound would apparently be seen one day and then be utterly lacking for several days following. In only one instance was the reaction observed each day after its first occurrence. Of the 75 cases tested 5 gave no evidence at any time of hearing the whistle; 7 showed a reaction only once in the ten days and were therefore disregarded for the same reason as quoted above; 41 gave a reaction and in succeeding days gave, once or more than once, a similar reaction to the same stimulus.

In only a few instances was the child observed to give the appearance of hearing the human voice. The most notable instance was that of the child who turned to the investigator while standing on the table on the sixth day, a full description of which is given in the section on muscular activity. Several other infants were observed to turn the head on the ninth and tenth day and fixate the face of the investigator who in each case was holding

the babe in her arms. The "reaction" seemed to be that of "listening" while the investigator talked or crooned to the child.

In each institution where the cases cited were observed the nursery was at the back of the building where little noise was heard from the street. In one place, however, the accident department was just below and across a narrow patio from the nursery and the ambulance would frequently swing into this fatio, by way of the alley, with a warning scream from the siren. Frequently when this occurred the investigator was standing before a number of the baskets observing the babies. At no time did she see any start or other evidence of a reaction to this sound.

Conclusion

New-born infants do not all give evidence of hearing in response to bell and whistle stimulation during the first week of life.

The average new-born infant gives no evidence of hearing ordinary sounds during the first two days.

Many infants give evidence of hearing from the third to the seventh day.

Some infants give the appearance of listening to ordinary talking or crooning before the tenth day.

TASTE AND SMELL

Definite stimuli to elicit olfactory and gustatory responses were not given. Some observations that contribute to knowledge of such responses during the first ten days of life were made. While the infant seems to be sensitive to strong odors or to distinctly different taste qualities according to previous studies, the experience in this present experiment would indicate they were not acute enough to detect human milk from different mothers nor from modified cow's milk. A number of children, due to a sick condition of their own mother, were given milk from other mothers who had more than enough for one child and who were willing to have it pumped for the needy child. Thus the infants sometimes had milk from another mother or mixed milk from a number of mothers or at times even modified cow's milk, without showing any lack of willingness to accept it and without presenting any notable facial expression or other unusual reaction. When, however, in the preparation presented to the child lactic acid was used it appeared to be distinctly displeasing to the child. The nipple was not seized as eagerly as when mother's milk was presented but was pushed from the mouth with the tongue rerepeatedly with facial expressions or contortions which seemed to indicate distaste or dislike. After the preparation with lactic acid was presented for a number of days in succession this dislike seemed to disappear, accomodation seemed to occur, and the milk was taken eagerly.

REFLEXES

A study of the reflexes in the newborn has occupied much time and interest, but reports are so conflicting and at times so incomplete, as to make the summation of results extremely difficult.

The multiplicity of description

seems to give confusion to the picture since the different experimenters describe their procedure, as well as the results, in differing expressions which are difficult to interpret in common terms. Failure to report the exact age of the child or range of ages of any specific division of a group showing one particular type of response also adds to the indefiniteness of results found.

Some state as Koffka (5):

"That a considerable number of reflexes are aroused by stimulation of the skin. Among these, one that is typical of the new-born infant is the so-called Babinski reflex, which after a few weeks is supplanted by the plantar and does not again appear in the normal adult."

Burr (2) reports that Gottfried Engother, 1905, found that in 232 children, in the first week of life, and with sound nervous systems, the *plantar consisted of dorsal flexion of* the toes (*Babinski*). M. A. Leri in 166 infants found extension of the toes on stroking the sole, the rule, at birth. John Lovett Morse concluded after the examination of 254 infants during the first twenty-three months of life that, "It is evident that there is no constant plantar reflex in the first year." In his own study Burr (2) examined 69 infants, from one hour to ninety days old, and reports,

"In 9 instances, though the toes moved, the movement was so erratic that I could form no judgment. In 19 others there was no movement of the toes, of any kind, no matter what part of the sole was stimulated. In 25 cases there was definite extension of the toes, and in 16 there was flexion."

Preyer (8) and Watson (13) both report the Babinski as present at birth.

Sherman (15) reports on this reflex,

"The reflex was elicited by stroking with a dull pointed pencil from the anterior plantar surface downward in the midline. When the stimulus was followed by extension of the great toe (positive Babinski), 5 additional stimuli were given in succession, within less than one-half minute. Age variation of infants examined was from one hour to twelve days. Flexion occurred in 57.3 per cent of the cases and extension in the remaining 42.7 per cent. When the stimulus was repeated as described above, the positive Babinski was quickly followed by flexion in 31 (75.6 per cent) of the 41 infants showing extension in response to one stimulus. The remaining 10 cases showed a persistent extension of the toes. The final response was a flexion in 86 (80.6 per cent) of the total 96 cases."

Since the Babinski reflex is said to be found in such a comparatively short span of time, two years or less, it is highly essential that note should be made of any deviation of its appearance, or disappearance as to point of time. *The consideration of this time* element may be one of the most important factors in disclosing the real significance of this reflex. Some questions which present themselves as worthy of study are:

1. In what percentage of children is it present at birth?

2. Is there any correlation between the condition of labor and consequent condition of the child with the presence or non-appearance of this reflex at birth?

3. Even though found in all races alike, as some investigators affirm, does it appear in all races at the same approximate age?

4. How wide is the range of time for its disappearance and is there any correlation between the health condition of the child and its time of disappearance?

In the study of this reflex by the present writer the stimulus was given to each infant three times on each foot each day, at the period when the child was awake and also three times on each foot each day when the child was asleep. A soft blunt pencil was used for the stroking. The leg of the infant rested across the palm of the left hand of the observer and the forefinger and thumb clasped the leg very lightly just below the knee. The stroke was begun between the great toe and the second toe and followed the midline almost to the heel. The reason for lifting the pencil before reaching the heel was because it was found that stroking the heel greatly accentuated the reaction of jerking away as though from tickle. Another notable bit of reaction was that the free foot almost invariabily pushed against the worker's hand as though to free the imprisoned foot.

There were 100 infants studied in all, including 68 whites, 9 Mexicans, and 23 negroes. In general the results were as varied as indicated in the reparts of the workers cited above. It should be remembered that this study covered only the first ten days of life, so that differences found here would not have the same interpretation as differences found in a wider span of time. In no case was the Babinski found on the first day. The following discussion is a consideration of the experiment done with the child awake. In the group of white infants 17 gave the reaction definitely the second day, 13, the third day, and so on as indicated in figure 2, all but 6 showing the reaction by the tenth day; 3, however, showing great variability, the reflex being present one day and absent the next. In the group of 9 Mexican children 1 gave the reaction the fourth day, 2 the eighth and 1 the ninth, the other 5 not showing the reaction at any time during the ten-day period. In the group of 23 negro children, 1 showed the reaction the eighth day and 1 the ninth, and the other 21 not at all in the ten-day period. This shows a definite racial difference in the early

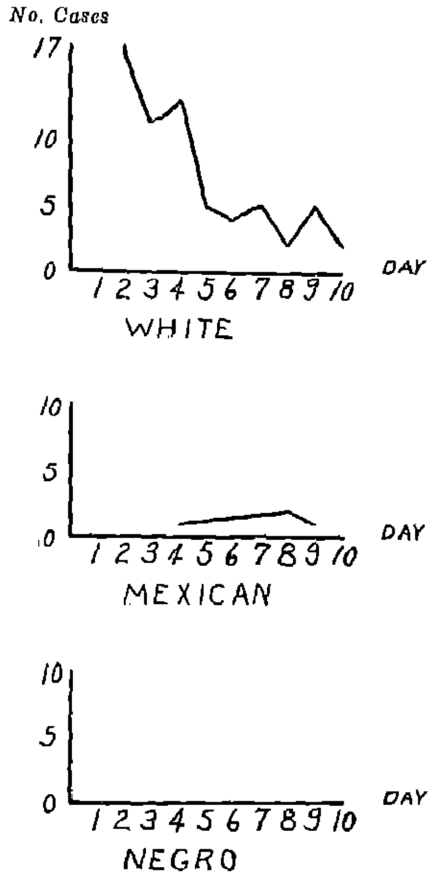

FIG. 2. APPEARANCE OF BABINSKI REFLEX

days of life. In regard to the colored infants it was noticeable that the reaction to other stimuli on the foot was not so acute as with the white. They did not jerk the foot away so quickly upon tickling or tapping the foot as the white children did.

Plate I, *A*, shows the reaction of one infant, on the third day, a definite plantar reaction which was secured from both left and right foot. Plate I, *B*, shows the same infant with the reaction of the fifth day (two days later), this time a definite Babinski. The picture was snapped, as can be seen, before the pencil had traveled very far and the fanning is not as complete as it was, a few seconds later, but, nevertheless, it clearly indicates the reaction. It proved in this group to be rather usual for the two feet to give the same reaction.

There can be no one type of reaction cited as appearing before that of the Babinski. In some infants the plantar was definitely seen. In many an erratic moving of the toes occurred which may or may not have anything to do with the stimulus. In some, and this was especially noticeable in the negroes, the stimlus applied in the earliest days elicited no response whatsoever but the foot lay in the experimenter's hand absolutely inert.

One interesting factor was seen a number of times with several of the white infants. Among those who developed the Babinski rather early in the ten-day period, and some others who remained in the hospital over the ten-day period, so this special experiment could be carried on into the eleventh and twelfth day, it was seen that the reaction did not wait for the stroke down the foot but occurred immediately upon the leg being taken into the hand in readiness for the usual stimulus. The interesting point here is whether the Babinski can be elicited by the stimulation of other areas and whether there may be at times a factor of learning involved. This reaction was seen a number of times under entirely different circumstances. It is clearly shown in one of the later illustrations in muscular activity occurring when the infant is hanging, supporting its weight by its own grasp of the investigator's fingers, Plate I, *C*.

Another peculiarity which came to light in this experiment was the fact that the reaction on stroking the foot is not always the same for a given infant when the stimulus is given with the child awake as it is when the child is asleep. For example: Ten of the colored children when asleep gave a very definite Babinski reaction, once, before the tenth day. This occurred only once with each child and between the sixth and tenth days. These infants, at no time, gave this reaction when awake. The white children did not show the same ratio of difference but 4 of them showed the same peculiarity, the Babinski appearing in the sleeping child before it did in the child when it was awake.

Although the Babinski reflex does not appear in all infants at the same time, and although it is variable in its constancy of appearance we are able to draw some rather definite conclusions concerning it.

1. In the majority of white children the Babinski reflex may be expected by the tenth day of life.

2. In the colored children the ap-

pearance of this reflex is delayed longer than in the white, not appearing in general until some time after the tenth day.

3. There seems to be a difference in time of appearance of the reflex when the child is awake and when it is asleep, usually occurring earlier in sleep.

4. The stroking of the sole of the foot probably is not the only stimulus which excites this reflex action.

5. A further study of this reflex may add something to the evidence on learning in these early days.

6. In some cases the reflex appears in the left foot before it appears in the right.

It may be that a prolonged and still more thorough study of this reflex will throw considerable light on the subject of prenatal and early postnatal development and on the earliest stages of learning. A further study of racial differences will be most interesting and possibly very enlightening.

THE CRY

Seemingly little has been done toward a careful study of the cry of the child. It has been accepted as one of the first and by some the very first activity of the new-born. It is so considered by Kant, Kirkpatrick (4), Lowden (6), Watson (14), Rasmussen (9), Gesell (3), Preyer (8) and Allport (1). Preyer (8) describes the first cry as purely reflexive but later as "Piercing and persistent in pain; a whimpering in an uncomfortable position; suddenly waxing to unexpected intensity and again decreasing quickly when something is desired and not obtained;" while Allport characterizes it as "weak, rhythmic, tremulus and unvaried," and Gesell speaks of it as "The very first behavior event after birth," and Watson (14) observes "The birth cry occurs at the moment the respiratory centers are stimulated after birth."

This report deals with the time and conditions of the cry responses. The quality of the cry as to pitch and pattern is merely described as apparatus for recording the sounds was not available for this study.

The cause for the first cry has not yet been determined, as there are several factors which seem adequate stimuli for this activity. It could well be the reaction due to the release from the pressure given by the uterine contraction and by that of the abdominal muscles as the fetus is forced through the pelvic passages in delivery. There are times when the sudden, abrupt, sharp cry, given immediately on delivery of the head, has every appearance of a protest against rough handling. This type of cry is more apt to occur in a normal, quickly expulsive delivery of the multipara. Such a cry is sharp, rather deep and given with a full intake of breath and is welcomed by the attending physician and nurse as indicative of complete expansion of the lungs. At other times the cry does not come until the entire body has been exposed to the air and may be due to the stimulus of the change of temperature from that experienced in utero to that of the room in which the delivery occurs. This cry is not usually so explosive or sharp and the inspiration is frequently not so deep as that which occurs with the cry coming immediately on delivery. It must frequently be further excited by tapping on the

soles of the feet or along the spine or by briskly rubbing the back. The child is never considered in the best condition until a vigorous cry with deep intake of breath has been secured. At times the cry is weak and more or less rythmic and has the appearance of being, not so much the result of a definite external stimulus as that of an inward discomfort or lack which might be described as an air hunger. Such a cry may indeed be concomitant with an incomplete expansion of the lungs. There is in it a complaining sound of discomfort. When such a cry as this comes as the first reaction, further stimuli are added until a sharper cry with deeper intake of breath is secured. It has been frequently noted with premature infants and other infants in poor condition at birth that each inspiration is accompanied with a little moan. It is difficult to determine whether this moan is indicative of discomfort or a mere whistle through the air passages.

When the birth is by Caesarian section the reaction seen is of two types: The one in which, for some reason, the mother has been kept under an anesthetic for a considerable period, shows all the signs of simple anaesthesia and after the lapse of a brief interval, (ten minutes in one instance) the infant cries feebly and breathes spasmodically and at the end of one-half hour shows normal breathing and crying. The other type delivered in this manner gives a sharp vigorous cry immediately upon being lifted from the uterus and continues crying vigorously while being carried from the operating room to the nursery. If the cry be the reaction to external stimuli in these cases, where the anaesthetic has not affected the infant, the cause would seem to be either the difference in temperature or reaction to handling.

The variation in the frequency, intensity, and pitch of this first cry seems to be closely related to the physical condition of the child and possibly to the type and length of the period of labor. There are times when the period of labor has been greatly prolonged and the child has every appearance of exhaustion that the cry is characteristically weak, short and intermittent. When the child is asphyxiated, as occurs at times when the cord is around the neck or when forceps have been used to interrupt prolonged and difficult labor, the cry may not come until some time after the intake of several breaths and also after definite muscular activity has been observed. One such case was noted in which the labor began at 11:00 a.m. on Monday and the first stage lasted until 1:00 a.m. on Tuesday (fourteen hours). The second stage lasted from 1:00 a.m. until 2:00 p.m. (thirteen hours) when, as very little progress had been made, it was interrupted by a mid-forceps delivery. Upon delivery the heart-beats were 35 per minute and no respiration, so that artificial respiration was set up and the alternate warm and cool bath was used for stimulation. Muscular activity (which will be described in the section on this subject) was set up before crying, and several inspirations were also observed before crying, and the child was fifteen minutes old before satisfactory crying was observed and thirty-five minutes old before spontaneous

vigorous crying was noted. Thus crying, though generally either the first or one of the first observed activities need not necessarily be so.

Within the first twenty-four hours the cry may take on very definite meaning. A child whose clothing has become wet will frequently in the first day give a cry of protest. At first, this is often a short, staccato cry with intervals of silence and muscular relaxation. It almost seems that the infant is waiting to see if any response will come to the demand for attention. If the response is prompt there is frequently no further sound during the handling in changing from wet to dry clothing nor on being laid back in the bassinet. If, however, no attention is paid to the first cry, others follow until in many cases the cries come in quick succession with very short intervals between for the intake of breath. If the infant works itself into a fury of crying, it will frequently continue during the process of handling and die into a wail and sobbing cry after being returned to the bassinet. In such instances there will frequently be seen the repeated intake of a sobbing breath after the child has dropped to sleep. When the cry reaches the state of continuous protest, it is generally accompanied by a vigorous kicking of the feet and a less rhythmic but rather constant waving of the hands. Some infants in this fury of crying will hold the breath until they are purple in the face giving a very good picture of the temper tantrum.

It is customary to find that a child which is crying in this unrestrained fashion will hush immediately upon being lifted out of its bed and remain quiet even when some moments elapse before its real wants can be given attention. This has been repeatedly observed as early as the first three days of life. In one nursery where there was an average of about twelve babies it was customary for the nurses to take up one child after another, dry it, and put it back in its basket. When all the babies were dried they would then be carried out to the mothers to nurse. Frequently babies would be discovered crying who were not wet. This could be accounted for by hunger as it was nursing time. Such babies, when handled and discovered to be dry, would be placed back in the basket awaiting completion of the preparation of all the babies to go out to nursing. Such babies were often observed to quiet down and remain quiet with widely open eyes during this waiting period, although no want, except possibly that of being handled, had been supplied. If, however, more than a limited amount of time elapsed before they were taken out to nurse they would again take up the cry. This had all the appearance of awaiting the completion of the satisfaction of their wants which as such could only be ascribed to learning.

The cry of the new-born varies in pitch, intensity, and continuity and to one accustomed to caring for babies has in it elements considered as expressing emotion. The emotions attributed to the infant on the basis of the difference in the type of its cry at different times are general discomfort, actual pain, and rage. Some people who care for infants would add a fourth as hunger. It seems difficult to distinguish the cry when hungry

from that of seeming general discomfort. The quality of the cry when expressing general discomfort is rather monotonous in pitch, staccato-like and intermittent at first becoming gradually more incessant but without very long tonal quality. The condition called pain is indicated by a rise in pitch from the inception of the cry to its completion. This gives the impression commonly spoken of as piercing or shrill. If the pain is accompanied by an increasing physical weakness this may drop to a moan, but even in this latter state the rising inflection is often noted. The cry attributed to rage is characterized by a greater duration of tone, although frequently the sound drops out entirely, while the mouth is still wide open, the breath is still held, and the face becomes almost purple. In this type of cry the mouth is more widely opened and the dropping away of the sound seems to be due to the closing of the air passages of the throat, while the mouth is still open. This would account for the purpling of the face and the whole picture is an excellent representation of rage whether the child has that emotion or not. The child crying in this manner can rarely stop crying as quickly as can be done in the cry from discomfort. It is in this type of cry that most frequently tears are seen in the very young infant, and this also is the cry which is most apt to be followed by intermittent sobbing breaths after the wants have been attended to and even after the infant has fallen asleep. This type of cry has with it a peculiar, characteristic muscular activity. The kicking of the feet is not so rhythmic as in the more monotonous cry ascribed to hunger. The movement is more abrupt and given with more vigor. The knees are frequently drawn up to the abdomen and both feet thrust out simultaneously instead of with alternating movement as is the customary action.

One infant, the seventeenth of this series, had every appearance of intelligently demanding attention as a pleasure satisfaction and knowing when it was granted. From birth it was an unusually pretty baby and consequently was fondled, by some of the nurses, more often than any of the other babies. By the sixth day it was noted in the nursery that this baby cried frequently when neither hungry nor wet and that the cry would cease immediately when and during the time it was fondled, generally taking up the cry as soon as it was put back in the bassinet. The infant seemed in a normal physical condition so the general conclusion in the nursery was that it desired attention, expressing its desire with a cry and showed satisfaction and content when this desire was granted. This tendency was well developed by the sixth day. As has been said above, the first cry may be entirely reflex but thereafter it very soon has the appearance of learning and of functioning as the expression of desire as well as emotion.

MUSCULAR ACTIVITY

The quiescent child assumes, in the period following close upon birth, a position somewhat similar to the position in utero. It has often been observed that in handling a new-born child during the first bath that intense crying nearly always is evoked when the lower limbs are straightened to a

line parallel to the line of the vertebrae, and also when the arms are lifted directly out from the side on a line from the shoulder. The writer has frequently thought that the necessary straightening of the limbs in completing the birth passage may be one of the important stimuli in setting up the all important birth cry. This seems to be a tenable assumption to make in view of the previously noted fact that this cry comes most unfailingly with the quickly expulsive delivery of the multipara and as this type of delivery means sudden straightening of the body line it may well constitute the first kinesthetic pain or discomfort and be the necessary stimulus for the cry.

In speaking of this early post-natal position Lowden (6) makes the comment "The legs are drawn up as in foetal life," and Moore (7) reports, "Immediately after birth, the child continued to lie in a position which closely resembled that of the foetus. The early movements were generally conditioned in range and direction, by the maintenance of this position."

The infant, however, exercises at times the greatest activity with arms and legs, kicking and slashing in all directions, and this with some infants from the moment of birth. Koffka (5), says, "We find the new-born child capable of movement whenever external stimuli come in contact with his senses; that is, whenever the equilibrium of his condition is disturbed." This activity is sometimes seen even before birth is completed. One infant, a multipara presentation, after the delivery of the head and the hand, quick as a flash before the rest of the body could follow grapsed the vulva. The expulsive power of the uterine contractions broke this hold, and it immediately grasped the cord so firmly it proved difficult to loosen the tiny fingers. The infants are frequently observed to grasp the cord, and also the instrument, the doctor's finger or a bit of gauze in the first few moments of life, even before the cord is tied. It has been said that this grasping is a reflex as they so quickly grasp whatever touches the hand, but like the sucking reflex, it is not invariably present.

The procedure in this test was as follows: After repeated trials the experimenter found that the infant grasped her thumb as readily and as firmly as it did the wooden rod used by some other worker. The use of the thumbs had the advantage, in that the experimenter could feel when the infant's hands were slipping and close her own figures down over the tiny ones of the infant before the baby fell and so prevent the shock of falling. It seems unwise to cause unnecessary startle to a new-born babe when we know so little of the condition of the nervous system at this time and so cannot judge what these shocks may mean in the ultimate development of the nervous system and emotional life.

Grasping is rather generally found and in some persists in a marked degree for the entire ten days and probably longer. Some workers have reported as very strong at birth and report the child as able to support its own weight with this grasp. The writer has found this true with a few isolated cases but not in the majority. With this group the strength of grasp has been

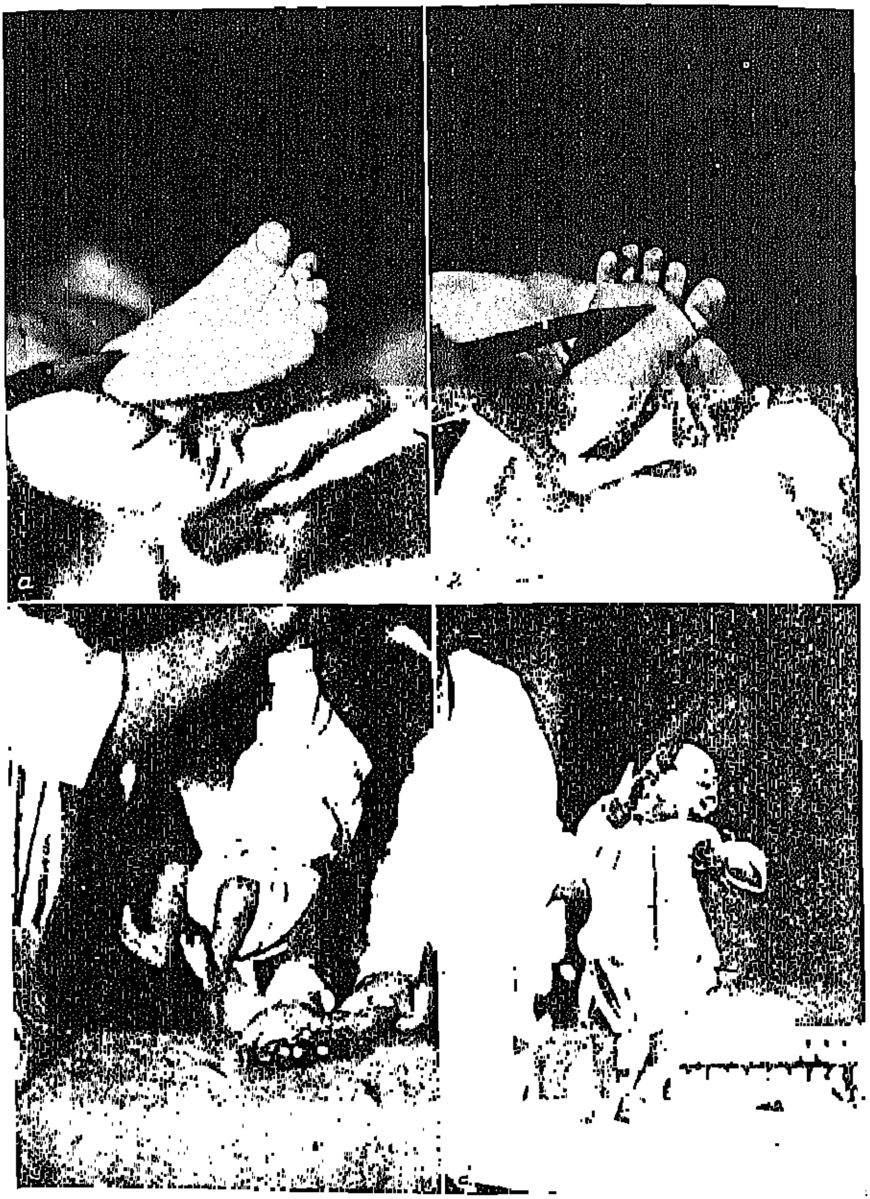

PLATE I. *A*, plantar third day; *B*, Babinski, fifth day; *C*, grasping, fifth day (note Babinski); *D*, standing, weight borne on feet, ninth day

sufficient, with some, to merely lift the shoulders from the table while the back, bent as a bow, permits the head and buttocks to touch; others were able to support the weight of the head and shoulders; and a very few, that of the entire body. One noticeable factor was that many of the infants who had the ability at birth to support a part or the whole of the body, would lose it in the days immediately following but after a few days, which time seemed to correspond fairly well with the period of starvation, would again show the ability. As the greater number could support only the shoulders or at most the shoulders and head this decline in ability referred largely to that power. It seemed a rather remarkable fact that nearly all the infants who acquired the ability to support the body weight retained it from the day acquired until the end of the tenth day when the study closed.

In Plate I, *C*, are shown the feet of a baby sustaining its own weight by the grasp of its hands. This is the characteristic position of the feet during this experiment, as they are always drawn up as in utero. It is the infant whose grasp during the act of birth was so remarkable. This picture also illustrates that the Babinski reaction may be induced by other stimuli. It is shown very clearly here and in both feet at the same time. This reaction frequently occurs during suspension. Here as in some other reactions studied, either practice increases the strength and surety of the reaction or else the reaction is more certain to appear with increasing age during these earliest days. Evidence of the ability to sustain weight is seen in figures 3, 4, and 5 which show the number of cases developing the ability, for the first time, in each of the first ten days of life. As reported earlier, when once present the ability was

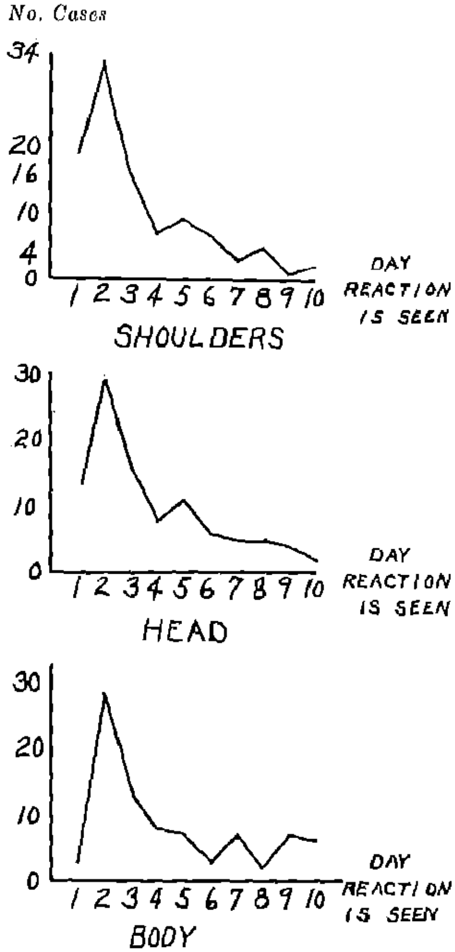

FIG. 3. GRASP WITH LIFT OF SHOULDERS; OF HEAD; OF BODY.—ENTIRE GROUP

never entirely lost during the ten days, although the infant could not always be stimulated to so react but only during its period of greatest activity, when it seemed to be most wide awake.

Another activity which may be indicative of the development of the infant is that of lifting the head when placed prone on the face. The procedure here was to place the child face down on a hard surface, table if possible, with the face down flat and the arms and legs straightened out from under the body as much as possible. The reaction was to turn the head to one side, lift the head, draw the knees up under the body, and the elbows in to the side with, *frequently*, the elbow or hands brought almost together

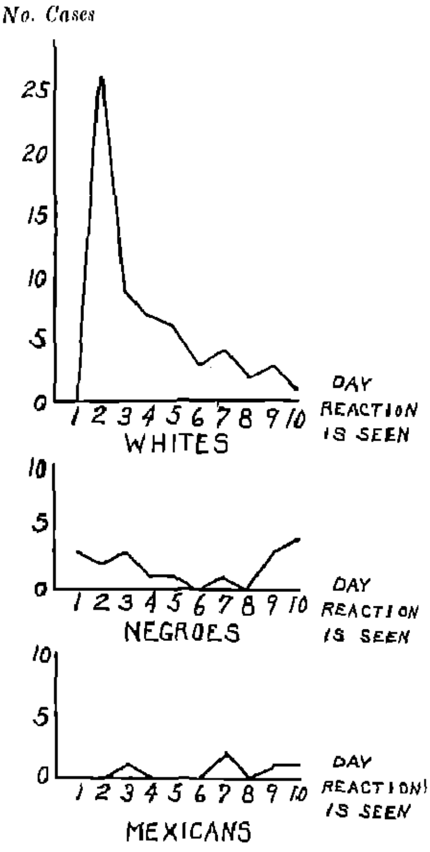

FIG. 4. LIFT OF ENTIRE BODY

under the chest. Some really striking results were seen from this procedure. One infant on the second day pulled the knees up, then pulled the elbows forward and raised the head at right angles to the line of the spine and turned the head from side to side as though looking about. After a few seconds of this the right arm straightened out so that the weight was transferred from the elbow to the hand and with a little extra push the infant rolled over on its back, to the left.

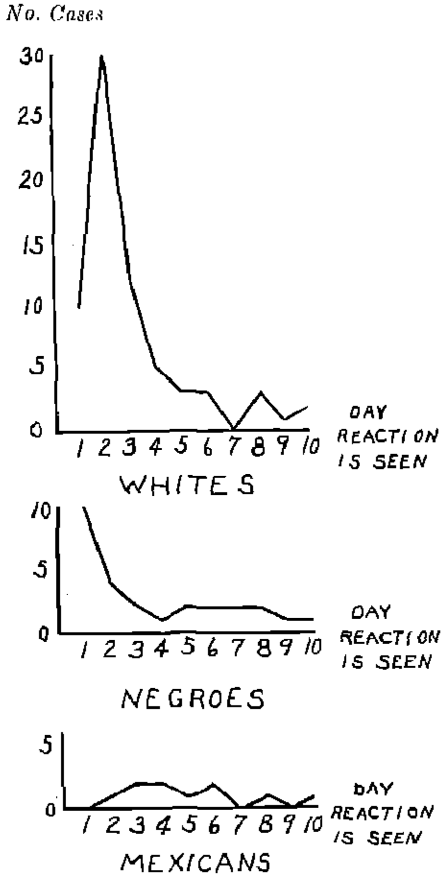

FIG. 5. LIFT OF SHOULDERS

The movement was accomplished so slowly, in all about forty-five seconds, that the infant was not at all frightened or disturbed by the change of position, but lay "looking" up and around it. Unfortunately not being prepared for this incident, no photograph was obtained of it. The same infant showed far greater facility, in movements of this kind, than the average, but never duplicated the whole procedure during the ten days. It may be well to note here that in much of this experimenting the infant was without clothing or had only a shirt and diaper. The average infant would probably develop better muscle control if not so hampered by restricting clothing and other barriers.

The position to which the infant brings itself when lifting the head is well illustrated in Plate II, *A*, where the knees are well forward and the elbows to the sides and the hands under the chest. With the head up in this manner he could turn it several times before it would drop down as though a bit too heavy for sustained support. The ability to lift both head and legs at the same time, resting only on the abdomen and pushing up with the hands is also illustrated in Plate II, *B*. This picture was taken on the tenth day but the same reaction was seen from the second day on. Plate II, *C*, shows the same position but this infant had very remarkable muscular strength. This picture taken on the sixth day represents a reaction seen from the first day. The child was delivered by a Caesarian section so was not exhausted by a long labor and delivery. The hands are both visible and it was notable that the baby, remaining in this position, head well up, would shift the weight from one elbow to the other and move the free hand turning it over. In the picture the weight is in the left elbow and forearm while the infant turns to the right and moves its right hand rather freely.

In this group, there were 10 infants that lifted the head well off the table during the first twenty minutes of life and of these 4 pulled the knees well forward, up under the body. As infants so often sleep more quietly on the face than on the back or side it is well to early learn their ability to move and adjust their position so that there need be no worry about smothering.

The infant in Plate II, *D*, also a Caesarian section case, showed in creeping an exceptional muscular development and good coördination. When the picture was taken, unfortunately, the baby had lost its balance and the head went down but the fold in the baby's blanket which acted as a table cover show the direction of travel. In all the baby made several inches of progress, and this on the fifth day. Another infant on the eighth day crept forward 6 inches (the full length of space on the table until the head touched the wall) twice in one minute. After the first forward creeping the experimenter pulled the infant back by the feet, thus straigtening the legs but the baby pulled up and covered the distance the second time. This infant covered the 6 inches with the head in the air. This, however, was an unexpected performance and the camera was not ready for a picture. The final picture of this series, Plate II,

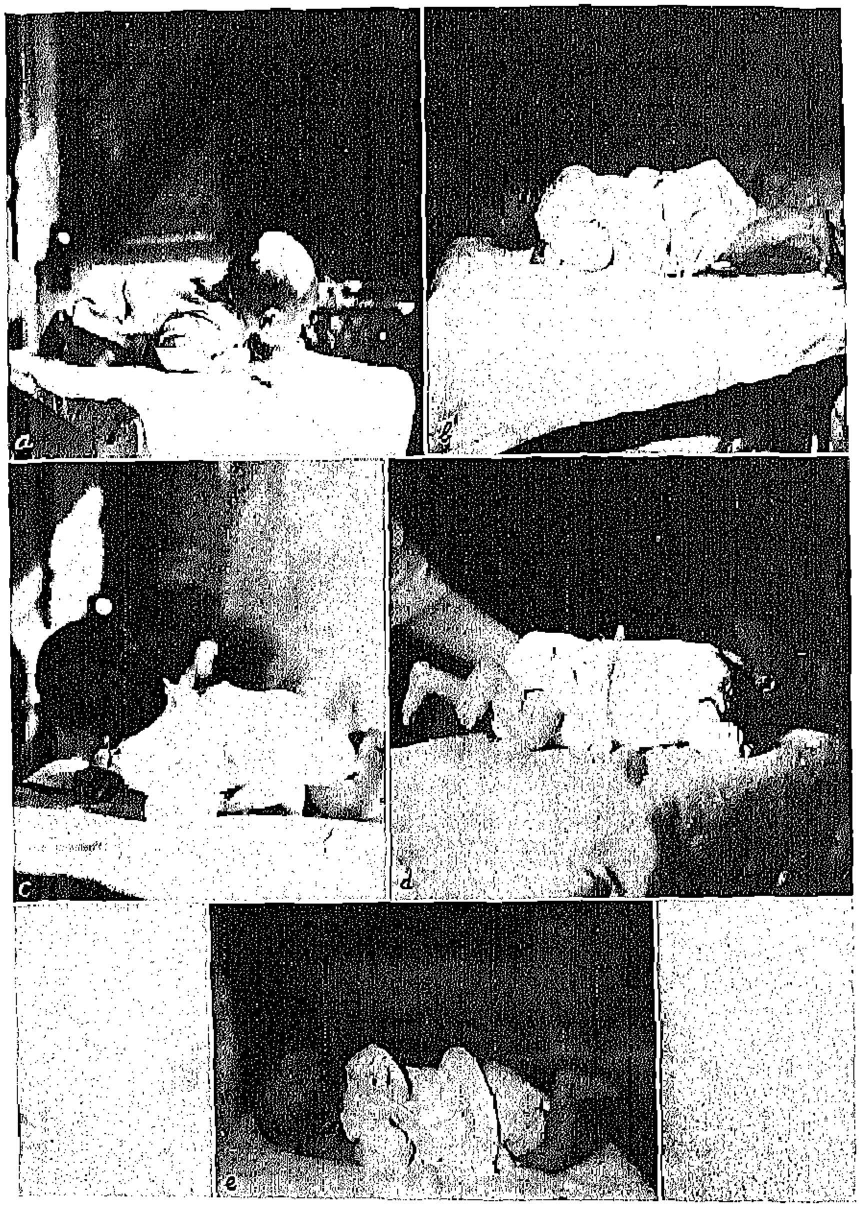

PLATE II. *A*, fifth day; *B*, second day; *C*, sixth day, seen first day; *D*, creeping, fifth day; *E*, frequent position—rarely lifting head—prolonged delivery

E, represents an infant whose delivery had been prolonged especially in the second stage and was finally interrupted by a forceps operation. The infant's head was much molded with considerable overlapping of the frontal and occipital parietal bones. This infant lifted and turned its head at times but was apt to collapse into this prone position or frequently to remain in this position seemingly unable to lift head or at least receiving no stimulus to lift up as is the custom of most of the babies in these first days. This is the same infant that showed the remarkably clear plantar reaction up to the third day and the equally clear Babinski on the fifth day and thereafter. Two other infants, when turned on the face and given something against which to press the feet, displayed the ability to move forward in creeping fashion in these first ten days. One moved across the table (18 inches) twice on the seventh day and was able to repeat the performance each day thereafter during the study. The other exhibited this ability the first time on the ninth day and repeated again on the tenth day. Each of these last mentioned infants was a primipara but, although delivered by different physicians, each was assisted by a mid-forceps delivery, and was in splendid condition showing good muscular activity immediately after birth, also gave a vigorous cry, opened their eyes immediately after delivery and gave an early appearance of all expected reactions.

In the last group of 35 infants in this study, 9 were primiparas with the assistance given of a mid-forceps delivery, in each case the doctor stating that otherwise the labor would have been greatly prolonged. It is interesting to note that 8 of these 9 showed notable muscular activity and a normal breathing immediately after birth; and the expected reactions in all other circumstances. They were not as exhausted as many primiparas who come through an unassisted labor.

An interesting form of coördination of movement was shown by a newborn who was delivered with forceps, had heart-beats, 35 per minute, and respiration not set up. Resuscitation was resorted to (the warm and cool bath). While the infant was in the warm bath before respiration was well set up it suddenly began a treading motion with its feet which was perfectly rhythmic and regularly alternating at the rate of 80 per minute, with the exception that in that time the left foot dropped 10 beats while the right foot lost none. A doctor and two nurses were present with the infant and all counted momentarily to observe the rhythm. It had all the appearance of swimming as the body was submerged all but the face.

Another bit of muscular strength and control is shown in Plate I, *D*, The incident is as follows: The writer picked this baby up to put it on the table for the picture of the head lifting. In putting the baby down its feet touched the table first and it immediately stiffened bearing all its weight on its feet. Realizing this the writer immediately removed the right hand and loosened the left hand so no support was given, although afraid to take the left hand from behind the baby for fear it would crumple and fall. The camera was in position so the writer cried out to the photographer, in an

excited and probably shrill voice, "Take the picture, quick, quick!," whereupon the infant lifted its head and seemed to look directly into the face of the writer and speaker and at the same time threw out its right hand and lifted the left arm and so maintained its balance. It was at this moment the picture was snapped. It is interesting to note the way the toes "dig in" to the table and the little fingers are extended as is characteristic in balancing. This baby not only stood alone on the ninth day but appeared to hear the sharp sound of command and seemed to fixate the speaker's face.

Conclusion

1. The new-born infant has considerable ability for sustained muscular activity and tension.
2. This strength and ability has a tendency to increase with the age of the infant.
3. The movements preparatory to lifting the head appear similar in all infants.
4. Creeping is possible even in this very early period, as is also the power to support the body weight on the feet.
5. In one instance this remarkable muscular strength and control was associated with appearance of hearing and fixating.

GENERAL CONCLUSIONS

The foregong study has led to some very definite conclusion concerning the variability in time of appearance and in constancy of human reactions at birth and in the ten days immediately following birth.

In its reaction to light, the infant tends to show a greater reaction in the first three to five days than at any subsequent time and generally reacts more strongly during the sleeping than during the waking periods. Although the eyelids open voluntarily, as one of the earliest muscular activities, there is very little evidence that the eye will follow a light or point of brightness during the first ten days of life. Occasionally, however, an infant will appear to fixate during these early days for a notable period of time.

The evidences of hearing do not come in these first ten days as a usual thing but they are occasionally found from the third to the seventh day. Such evidences usually come in response to a sharp sound or high tone although more rarely the infant gives the appearance of listening to ordinary talking or crooning before the tenth day.

In these early days the infant seems to be sensitive to strong odors or to different taste qualities; but to have the ability to adapt quite readily to that which at first seems distasteful.

Much has been said about the appearance and significance of the Babinski reflex in the infant. Although it does not appear at any given time and although it is not always constant after its first appearance some rather definite conclusions have been reached in this work. As an example, we find in the majority of white children this reflex may be expected within the first ten days, while with colored children it is rarely seen by that time. Also there seems to be a variation in the age at which it can be elicited in the

child awake and in the child asleep. The stroking of the sole of the foot is not the only stimulus which excites the reaction and there seems to be a tendency for the reaction to appear in the left foot before it is seen in the right.

One of the first activities, observed, namely, the cry, certainly shows wide variation in pitch, intensity and continuity, and if carefully studied may throw much light on the early development of emotions. While the first cry may be merely a reflex, early subsequent cries certainly bear the appearance of the result of learning.

The new-born infant has considerable ability for sustained muscular activity and tension, and this strength has a tedency to increase with age in the normal child. The movements preparatory to lifting the head, when lying face down appear similar in all infants and rather more purposeful than random. Creeping is possible with some infants in the first week as is also the power to support the entire body weight on the feet.

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Comparative Youth

The Physical Aspect*

T. Wingate Todd

EPIPHYSIAL UNION

IT IS sufficiently obvious that the actual duration of infancy, childhood and youth varies enormously in different mammals. A rat reaches skeletal maturity in little more than two months, a dog in less than two years, a gorilla in approximately seven years[1] and a human being in about twenty. The relation of these periods to total life span cannot at present be estimated and indeed in all creatures except man the duration of life is a matter of accidental environment: it often terminates soon after or even before maturity is stabilized. Hinton, for example records his experience that in many thousands of modern and fossil arvicola (a field mouse) he has met with only two skeletons in which the epiphyses are united (7).

Elsewhere we have shown that current estimates of the age of union of epiphyses in man are inadequate in that they unjustifiably postulate an inherent great variability in time relationship which altogether obscures the age-order of union. While it is true that there is variability and that the scatter is greatest in the period between eleven and fifteen years of human life, the assumption of natural variability is unwarranted. Investigators have been misled by circumstances.

First the amount of skeletal material upon which the classic and traditional estimates are based is altogether too scanty for reliance. Observations have been copied from one account to another with slight alterations based upon evidence of no real worth. Most modern accounts can be traced to that of Henle in Gottingen in 1871 (6).

Secondly, radiographers, relying upon the essential accuracy of accounts in anatomical texts and lacking the actual material with which to compare their roentgenograms, have assumed reliability for their observations on date of union of massive epiphyses like those at the knee or hip. They have failed to realize that the medley of overlapping shadows renders impossible the reading of such roentgenograms without a thorough collateral training on actual anatomical material. They have not realized, as yet, that the occurrence of Hellman's stages (5) in preparation for union confuse the roentgenographic appearance for large diaphyso-epiphysial junctions. Their observations on these areas, numerous though they be, carry no weight at all in spite of impressive figures.

Thirdly, investigators have failed to

* From the Hamann Museum, Western Reserve University, Cleveland, Ohio.

recognize the peculiar complexities[2] of the human maturation schedule, being unaware of the manner in which this grows out of the primate pattern with extensive delays and scatter during puberty and the prepubertal period but presenting equally striking uniformity before and after these years. The evident erratic character of epiphysial union in hand and foot, occurring as it does in this period of irregularity, is no criterion of the time relationship of skeletal maturation elsewhere.

In this confusion it is imperative that the whole problem of skeletal maturation be investigated afresh and the human pattern elucidated by comparison with those of other mammals. Since we have only the scantiest information regarding the time relationships of the various features of skeletal maturation in mammals it is obvious that we start by investigating the maturation pattern without consideration of chronological age. Our themes then must be four, taken in series, and for the present our attention will be directed to actual epiphysial union.

1. The order of epiphysial union.
2. The time relationship of epiphysial union.
3. Experimental and other evidence of modifications in this time relationship.
4. Local expression of irregularities in skeletal maturation in epiphyses which ossify only in part like those of the human clavicle and symphysis pubis.

Some years ago Stevenson, under my direction, published an account of the age order of human epiphysial union in one of the most stable periods of human development, namely the early adult years between eighteen and twenty two (14). Our conclusions, there stated, have often been called in question but never proved inaccurate. Critics have produced no valid material to justify their objections. Some have relied upon their assumption that without control of observation upon actual skeletons they could identify union by roentgenographic methods, altogether oblivious of the fact that overlapping shadows present a misleading appearance of continuity in bone tissue (11, 12, 13). Other critics have utilized mammalian material in which the occurrence of pathological anomalies has been conceded (1, 2). The Hamann Museum of Western Reserve University, alone among institutions, houses a large enough collection of human skeletons from known individuals to make such an inquiry possible and we stand in no fear that our observations will ever be successfully refuted.

For the elucidation of this problem of age-characters in the skeleton we have at our disposal and have carefully studied eighteen hundred human skeletons of known persons including more than two hundred young people and adolescents, more than a thousand mammalian skeletons including one hundred and fifty anthropoids. All the human material and most of the mammalian skeletons are in the Hamann Museum. The majority of the remaining mammalian skeletons were examined, by the courtesy of Sir Arthur Keith, in the Museum of the Royal College of Surgeons, London. A comparatively few skeletons were found in

the American Museum of Natural History, New York, the National Museum, Washington and the Field Museum, Chicago. Observations on certain of the skeletons in these latter American collections were made by Stevenson but all the Reserve and College of Surgeons material and most of the small American series have been studied by myself.

THE DETERMINATION OF ORDER OF UNION.

It seems a very simple matter to arrange the epiphysial fusions in order but in practice difficulties arise through the imperfections which are found in skeletal material even under the most assiduous care. It may be, for example, that in skinning the animal the fingers and toes have been mutilated, or that in transport home from the field a part of one limb has been lost or possibly important bones like the clavicles. Then again some bones are missing in certain animals or so greatly modified that they lose their significance and themselves constitute a problem for investigation. Notable among these are clavicles, fibula, metacarpals, metatarsals, cervical vertebrae, pelvic girdle and hind limbs. Even if it is desired only to compare sequence of union within a single mammalian order some scheme must be devised to eliminate this difficulty. If the investigation be of larger scope the need is correspondingly more urgent.

The method used is, in essence, very simple. The several stages of fusion are evaluated. The evaluations for a particular epiphysis in all skeletons are summated and divided by the total number of skeletons in which that epiphysis is found. The record is kept in its fractional form and, for comparison, is reduced to a least common denominator for the group of material under investigation. In a certain group of rodents, for example, there were 51 skeletons. Of these, owing to defects, 50 had humeri, 49 had radii. Only 32 had acromion processes since these bone elements are often lacking in rodents. To compare the results of our observations on these epiphyses our fractional figures had to be reduced to a least common denominator of 51. The actual evaluations are no union 0; commencing union 1; recent union 3; complete union 4.

The precise amount of union displayed in any series of skeletons depends on the scatter of the several skeletons over the life span. So many diverse factors enter into the accidental determination of the series that it is unnecessary to make an enumeration. Some interpretation can be attempted in the chapters dealing with the several orders. Clumping, or, at the other extreme, wide dispersal of union in the several epiphysial sites may be merely an expression of the portion of the life span covered by the particular series of skeletons.

FEATURES OF EPIPHYSIAL UNION

Most epiphyses, as Parsons showed (10), form a more or less perfect cap so that, when embedded in deep soft tissue as at the hip, or when large and complicated as at the knee, the roentgenogram may yield but little information of the precise state of the diaphyso-epiphysial junction except to those observers who have carefully checked their roentgenograms on the

actual skeleton from which they were made. The only workers who have had adequate opportunity to do this are the little band of investigators in Western Reserve University.

Before actual union occurs there is a narrowing of the diaphyso-epiphysial gap, described by Hellman (5), with a slight condensation of bone tissue at the adjacent surfaces of diaphysis and epiphysis shown on roentgenograms as an indefinitely outlined whitish margin. When union commences it occurs erratically in the depths of the diaphyso-epiphysial plane and occurs last on the surface of the bone. The skeleton plainly shows first the close approximation of epiphysis to shaft with progressive narrowing of the gap and later an increasing fusion of the two bone elements. In the fresh bone there is a fine red line marking the site of union for about six months after the fusion is perfected. This stage we call recent union. The red line then becomes transformed into a white scar which in some places, lower end of radius and ulna for example, disappears usually in a few months but in others, such as the knee, may remain throughout life in modified form. When the white scar has developed we call the union complete. These features are just as plainly apparent in other mammals as in man and can be readily demonstrated by a little careful dissection.

COMPARATIVE ORDER OF UNION

Among existing orders of mammals there are 2 which are essentially primitive, providing opportunity for study of epiphysial union, namely the insectivores and the rodents. The former have adopted a safe mode of life which enables them to live long. They are comparatively rare in collections, are difficult to procure and, because of their relative immunity to capture, are often aged when obtained. The rodents on the contrary are easily obtainable and often gregarious. Then tend to die young, in groups,[3] so that they are numerous in museums and their skeletons usually show the unmistakable signs of adolescence or early maturity. Hence we shall utilize them as a starting point for our description.

It is not my intention at this time to present a detailed discussion of the order of union among the skeletal epiphyses. It will be sufficient to point out the general similarity of order pattern as an indication of the manner in which epiphysial union, as a manifestation of skeletal maturation, may be utilized to identify comparable points in the life-spans of very different animals. I have drawn up a table based upon the records of somewhat less than four hundred mammals from some of the earlier work, the later amplified tabulations being not yet completed. This table includes simply the epiphyses of the long limb bones excluding those of hand and foot. It covers all the primates and makes use of the rodents as an illustration of the relatively slight divergence to be found between vastly different mammalian orders.

The distal epiphysis of the humerus is the first to unite except in gorilla where the proximal epiphysis of the ulna unites slightly before it. The last epiphysis to fuse is the proximal end of the humerus though in orangs and gorillas the distal ends of radius and ulna lag somewhat behind it.

There is no great lapse of time between union of these three epiphyses in any of the higher primates. In man and chimpanzees radius and ulna precede humerus by a very short time and in gibbons all three unite together.

The medial epicondyle of the humerus closely follows the distal extremity in date of union. In anthropoids, except gorilla mentioned above, and in man the proximal end of the ulna unites in point of time between these epiphyses. There is however no great alteration in date of union of proximal ulna in these animals from the date in lower primates. In all it has attained a much earlier union than in rodents in which it fuses comparatively late. This epiphysis is the only one of those in the arm under consideration to show a marked change in order of union when primates and rodents are compared.

As for the epiphyses of the leg, those at upper end of femur always unite first in primates. In man and the large black anthropoids they are comparatively early in their fusion. Then follow distal tibia and fibula. Distal femur with proximal tibia and fibula unite last of the leg epiphyses and close together in time, the precise order varying slightly from one genus to another. In rodents the order is but little different. The same three epiphyses are the last to fuse but distal tibia and fibula climb to a position among the fusions at upper end of femur.

Were it possible to continue this survey without regard for space it would be possible to demonstrate a like similarity in epiphysial union over the entire skeleton. This demonstration must however await the complete publication of our researches. The claim has been illustrated that throughout the mammalia there is a definite and approximately uniform order of epiphysial union, modified indeed by influences quite imperfectly understood, but holding valid in the main. This uniformity is definite enough to enable us to identify the several phases in maturation of the mammalian skeleton and to compare with assurance identical phases in animals belonging to a single order. For the present purpose it suffices to restrict our attention to the anthropoids.

TOOTH ERUPTION AND SKELETAL MATURATION

From the examination of our immature anthropoid skeletons it is apparent that tooth eruption and epiphysial union progress together and that their inter-relationship is similar to that shown in human skeletons.

The subject of tooth eruption in anthropoids has been made a special study by Krogman (9) whose results are set forth in an article shortly to be published.

The dates of eruption of canines, premolars and second molars in man are subject to quite considerable variation but this, as we shall see, is a necessary corrollary of the specific human adolescent lag which we are later to discuss.

Tooth eruption, like skeletal maturation of which one feature is epiphysial union, can be violently disorganized by certain pathological states. In a series of thyroidectomized sheep for which we have to thank the late Professor Sutherland Simpson and

Doctor H. S. Liddell of Cornell University we have found repression of all skeletal maturation so that tooth eruption and epiphysial union alike are greatly delayed. Further than this one need not go at the moment. It is evident however that conditions of captivity may retard skeletal maturation. This, I believe, may be the explanation of Zuckerman's claim, from the study of five chimpanzees at the London Zoo, that dates of tooth eruption in the chimpanzee are practically the same as those for man (18).

Basing our conclusions in the first place upon such fragmentary observations as have been made upon the probable actual chronological age of anthropoids examined in captivity and upon the records of their tooth eruption, but amplifying these with our own quite extensive examinations of anthropoid skeletons we may state in general terms that an anthropoid of twelve months corresponds in development to a human being of two years, that an anthropoid of four years corresponds to a child of five, an anthropoid of six years to a child of twelve and an anthropoid of seven years to a youth of twenty.[4] For this last conclusion we are indebted to the comprehensive work of Doctor Yerkes on Congo, a mountain gorilla (15, 16). The skeleton of this animal, approximately seven years old, was sent to Doctor A. H. Schultz in Baltimore. Through the courtesy of Doctor Schultz both Doctor Krogman and I examined the skeleton and each independently assigned to it a maturation comparable between eighteen and nineteen years of human life, utilizing for this decision the epiphysial keys prepared by Stevenson on the Reserve human skeletons (14).

The opinion of Keith in 1899 (8) that the permanent teeth of the anthropoids are probably in place by the fourteenth year should perhaps be somewhat modified by the observations on Congo in which the permanent set was already complete except for the third molars and the canines.

Krogman working upon our anthropoid and Old World Ape material has stated the dates of eruption of teeth in terms of epiphysial union (9). On the basis of this comparison he notes that although tooth eruption in these primates does not slavishly follow the human pattern, yet, for practical purposes, at a given comparable epiphysial age the permanent teeth erupted are the same. "This does not bespeak identity in actual years but infers a practically uniform chronological sequence. It must be recognized that the entire growth process in anthropoids is accomplished in fewer years than in man, especially after the period of infancy."

THE ADOLESCENT LAG

The comparison of weight curves during the first year of life made by Dodge (3), shows a progressively diminishing scatter in both males and females. The Misses Hejinian and Hatt, working at the Merrill-Palmer School (4), have shown the stable and rather uniform character in progress of development in boys and girls between one and five years. Our own observations during the past four years on boys and girls from five to thirteen years, now in process of publication, demonstrates that there is a minor pro-

gressive acceleration of female skeletal maturation between six and eight years. During the period eight to nine years the females slow up so that the male maturation reaches that of the female at about the latter date. At ten years the girls again advance ahead of the boys and, shortly after the thirteenth birthday, are already at the stage reached in the boys about the fifteenth birthday. Thereafter they slow down once more and at about sixteen years and a half the maturation of the male skeleton has finally caught up that of the female. From this date onwards an increasing stabilization is significantly apparent and the years eighteen to twenty-two are remarkable for the uniform maturation of the skeleton in males and females which both keep to the same schedule. It is the stabilization at the approach of adult life between the eighteenth and twenty-second birthdays which we emphasized in Stevenson's article. Such adverse criticism as this demonstration has met is based upon lack of understanding of the manner of human maturation in relation to that of other primates and to a fallacious belief in the ease with which roentgenographic shadows of the larger diaphyso-epiphysial areas can be interpreted. We must again emphatically point out that those who assume their infallibility in interpretation by roentgenograms alone of Hellman's stages B. C. D. in the shoulder, hip, knee and even elbow, wrist and ankle, without careful training upon the actual adolescent skeletons themselves, from which the roentgenograms have been made, are taking upon their shoulders a heavy and, likely enough a crushing, burden.

Such peculiarities as are shown in the female accelerations between six and eight years and between ten and sixteen years, cannot occur without considerable scatter. It is therefore quite to be expected that we should find, as we do, a greater individual variability among girls than among boys. It is here intended simply to lay stress upon general trends and not to detail specifically the range or distribution of examples. Many girls show no greater progress than the boys and some are even retarded behind the boys. Questions relating to retardation and acceleration must be dealt with in another communication.

The scatter, both among boys and girls is greater in the period of ten to sixteen years than at earlier ages. In the light of our anthropoid studies this is intelligible. It is a reasonable corollary of the characteristically human and greatly extended developmental period of adolescence.

This adolescent lag in human skeletal maturation, with its corollary the adolescent scatter, is quite the most fascinating and instructive problem which we have opened up in our studies on growth. It is the key to better understanding of multitudinous complexities and difficulties of the second decade.

Adolescence is a figment of the mature imagination. The word itself is abhorrent to those to whom we apply it. The gorilla like all other mammals leaps from childhood to adulthood. The inception and maturation of its adult features cover but a period of months. A characteristic feature of man is his adolescent lag whereby the development of his adult characters occupies as many years as it does

months in the gorilla. This is the modern counterpart of the doctrine of human foetalization. When we note the divergence between different young people in the date and order of appearance of adult characters[5] we are merely observing in exaggerated perspective similar irregularities which are common to all mammals but are emphasized in mankind on account of his adolescent lag.

SUMMARY

1. A detailed and comprehensive analysis of mammalian epiphysial union, accompanying a quite exhaustive investigation of this problem in man, shows the essential unity in order and relationship of epiphysial union throughout the mammalia.

2. The occurrence of Hellman's stages B and C, namely the approximation of epiphysial bone to diaphysis, before union is begun, can easily be identified in hand and foot, but in the larger areas, shoulder, hip and knee, and even in elbow, wrist and ankle, obscures the precise state of the diaphyso-epiphysial plane and renders interpretation fallacious.

3. In order to check one's observations on the roentgenogram it is essential to examine anatomically the very bone roentgenographed. Lack of such training has led many honest workers into error. They have confirmed the existing fallacious textbook statements of date of union without realizing the inaccuracy of the method used.

4. Applying a simple valuation to the state of the diaphyso-epiphysial junction it is possible to express numerically the order of union and the relative period over which, for that particular group of skeletons whether human or mammalian, epiphysial union takes place.

5. The dates of epiphysial union and eruption of permanent teeth are related so that they may be regarded, for this purpose, as different aspects of the same phenomenon. Both order-pattern and date of union or eruption can be and are modified by pathological conditions of the body.

6. There is a chronological linkage for both epiphysial union and eruption of teeth which is normally stable for a particular animal but varies with the order or genus.

7. The special character of the primates is a lag of maturation throughout infancy and childhood. Nevertheless even in them adult characters quickly reach complete development once they have appeared.

8. The particular feature of man's development is his adolescent lag, and the scatter in individual variation which is most pronounced between eleven and fifteen years. The most stable and uniform periods of human skeletal development for both males and females are between one and five years and between eighteen and twenty-two years.

NOTES

Having had the privilege of submitting this manuscript to Professor R. M. Yerkes for criticism and comment I take the opportunity to add certain notes which will assist in

TABLE 1

Order of epiphysial union with number of examples in each series

MAN (151)	GORILLAS (27)	CHIMPANZEES (27)
Hum. dist.	Ulna prox.	Hum. dist.
Ulna prox.	Hum. dist.	Ulna prox.
Hum. med. ep.	L. troch.	L. troch.
L. troch.	Fem. head	Fem. head
Fem. head	G. troch.	G. troch.
G. troch.	Hum. med. ep.	Hum. med. ep.
Tib. dist.	Rad. head	Rad. head
Fib. dist.	Tib. dist.	Fib. dist.
Rad. head	Fib. dist.	Tib. dist.
Tib. prox.	Fem. dist.	Fem. dist.
Femur dist.	Tib. prox.	Tib. prox.
Fib. prox.	Fib. prox	Fib. prox.
Rad. dist.	Hum. prox.	Rad. dist.
Ulna dist.	Rad. dist.	Ulna dist.
Hum. prox.	Ulna dist.	Hum. prox.

ORANGS (22)	GIBBONS (11)	OLD WORLD APES (77)
Hum. dist.	Hum. dist.	Hum. dist.
Ulna prox.	Ulna prox.	Hum. med. ep.
Hum. med. ep.	Hum. med. ep.	Ulna prox.
Rad. head	Rad. head	Rad. head
L. troch.	L. troch.	L. troch.
G. troch.	G. troch.	G. troch.
Fem. head	Fem. head	Fem. head
Tib. dist.	Tib. dist.	Tib. dist.
Fib. dist.	Fib. dist.	Fib. dist.
Tib. prox.	Tib. prox.	Fib. prox.
Fib. prox.	Fib. prox.	Fem. dist.
Fem. dist.	Femur dist.	Tib. prox.
Hum. prox.	Rad. dist.	Rad. dist.
Rad. dist.	Ulna dist.	Ulna dist.
Ulna dist.	Hum. prox.	Hum. prox.

NEW WORLD MONKEYS (36)	LEMURS (30)	RODENTS (136)
Hum. dist.	Hum. dist.	Hum. dist.
Hum. med. ep.	Hum. med. ep.	Hum. med. ep.
Ulna prox.	Ulna prox.	Rad. head
Rad. head	L. troch.	L. Troch.
L. troch.	Fem. head	Tib. dist.
Fem. head	Rad. head	Fem. head
G. troch.	G. troch.	Fib. dist.
Fib. dist.	Fib. dist.	Ulna prox.
Tib. dist.	Tib. dist.	G. troch.
Fib. prox.	Fib. prox.	Fib. prox.
Tib. prox.	Tib. prox.	Rad. dist.
Rad. dist.	Fem. dist.	Ulna dist.
Ulna dist.	Rad. dist.	Fem. dist.
Fem. dist.	Ulna dist.	Tib. prox.
Hum. prox.	Hum. prox.	Hum. prox.

clarifying questions which arise from the conclusions given in the text and the manner of presentation.

(1) R. M. Y. These figures do not apply to growth (size) or sexual maturation. The gorilla assuredly is not fully grown short of twelve years or more. Congo was growing rapidly when I last observed her.

T. W. T. Maturity in weight, sex and skeleton are not synchronous. Our records on young adult women show increase in weight but not in dimensions after skeletal maturation. Full female stature is attained on the average just under sixteen years, skeletal maturity of long bones at twenty but weight continues to rise thereafter.

(2) R. M. Y. Are there not comparable complexities in the great apes. Though at present we have no measurements of psychobiological development in relation to age in any anthropoid ape I should like to have the question of fact raised.

T. W. T. There undoubtedly are complexities similar in principle in anthropoids as in man. Observations on the growth and tooth eruption of our living South American monkeys indicate a pattern not dissimilar throughout primates but our distinctions are not yet fine enough. I intended to imply a pronounced difference between primates in general and anthropoids in particular on the one hand and non-primates of the other, by my comparison of dog and gorilla. I might have mentioned that skeletal maturity is reached in sheep before the third birthday. Uniformity of epiphysial picture throughout period of tooth eruption between appearance of second milk molar and second permanent molar indicates "concentration" of physical development (see also Bingham, H. C.: Growth and development of chimpanzees, Am. J. Phys. Anthropol., 1930, vol. 13, pp. 433–468). Confusion in eruption order of second permanent molar and premolars in anthropoids and Old World apes indicates the complexity to which you refer (see Krogman 9).

(3) R. M. Y. Do you mean when kept in colonial groups, or that they die in groups.

T. W. T. I referred to the finding of large numbers of skeletons commingled in one area. Paleontologists repeatedly comment on this. We have definite evidence of "mouse years" and migrations of hosts of such rodents which are cut off by death together. As such collections emphasize a uniformity of general epiphysial condition and this corresponds to the period of early maturity of the animal (averaging about seventeen to eighteen human years) I suspect such migrations to be a kind of "vernal urge."

(4) R. M. Y. Behavioral data would suggest less marked divergence, say six to ten and seven to fourteen years. So far there is no check observation on skeleton development aside from tooth eruption. I do not think Congo was comparable psycho-biologically with a woman of twenty, rather I should guess fifteen years.

T. W. T. I am dealing solely with physical aspects, namely skeletal differentiation and tooth eruption. In her skeleton Congo was between eighteen and nineteen human years; John Daniels I, in his skull, more than five human years and less than twelve. Dwina (See Bingham (2) above) was twelve and a half upon our records in human years. Bingham's chronological guess was four years eight months. I do not emphasize the exact number of years but merely the human lag. See also Krogman (9).

(5) R. M. Y. Would it not be safer to limit the statements to structural characters since our data on functions are so limited (especially in case of gorilla)? I suspect you are substantially correct but we certainly could not produce the supporting observations for behavior.

T. W. T. I did intend so to limit my statement but desire to project the reader's thought into the possibility of similar findings in other fields. We have little to guide us at present but tooth eruption and a plainly demonstrated expedition in epiphysial union, once it starts, after eruption of the second permanent molars.

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The Acquisition of Motor Skill in Young Children

A Study of the Effects of Practice in Throwing at a Moving Target[1]

J. Allan Hicks

THIS study is concerned with the effect of specific practice upon the ability of young children to hit a moving target by throwing a ball. Fundamentally the problem is to what extent young children improve in complex motor skills as a result of specific practice and to what extent as a result of other factors such as structural maturation and general practice which has a direct bearing on the specific skill.

The effect of specific practice was determined by giving 1 of 2 comparable groups of children practice in throwing at a moving target under controlled conditions while the other group was not given such practice. The added increase in skill of the practice group, as shown by tests, is attributed to specific practice because the other factors which might affect this increase can be assumed to be similar for the 2 groups.

A moving target test was devised and was the main test in this experiment. The Blackhurst arm strength test (2), the Wellman tracing path test (3), and the perforation test (1), were used as supplementary motor tests. This paper is a report of the results on the moving target test. The results on the supplementary tests in comparison with this test will be reported in a subsequent paper.

The subjects were 60 children ranging in age at the beginning of the experiment from two years, seven months to six years, five months. The distribution according to age and sex for the practice and control groups later described is given in table 1. The total group included 12 three-year-old children, 18 four-year-olds, 18 five-year-olds and 12 six-year-olds.

The 60 children were first given the initial moving target test and the three supplementary motor tests. They were then divided into two groups which were comparable in performance on the initial test on the moving target. The mean score of each group was 11.7 with a standard deviation of 5.7 for the practice group and 5.6 for the control group. As

[1] From the Washington Child Research Center. This study was completed while the author was a scholar in child development of the National Research Council at the Iowa Child Welfare Research Station. A detailed account of the study will be published as an Iowa study in child welfare.

shown in table 1, both groups were also comparable in age and sex distributions.

The 30 children in the practice group repeated the moving target test once a week for eight weeks. For convenience in carrying out this practice program an equal number of the children were tested on each of the school days, Monday to Friday inclusive. The one week interval was kept constant by testing the same children on the same day of the week throughout the experiment. A few deviations

TABLE 1

Age and sex distribution of children in practice and control groups for the moving target test

AGE	BOYS		GIRLS		TOTAL
	Group				
	Practice	Control	Practice	Control	
years					
3	2	2	4	4	12
4	4	4	5	5	18
5	3	3	6	6	18
6	4	4	2	2	12
Total	13	13	17	17	60

from this schedule were necessary because of absences but of the 240 practice records but 19 were off schedule more than three days.

At the end of the eight weeks' practice all children were given the moving target test once each week for two weeks. This gave the practice group an initial test, eight practice tests and two final tests, a total of eleven. The control group was given the initial test and the two end tests, a total of three practices. Ten throws were given during a test period so that each child in the practice group threw 110 times at the target and each child in the control group 30 times.

Approximately three months after the initial tests the strength, perforation, and tracing path tests were given again to the 60 children. As nearly as possible the second series of tests was given in the same order as the first so that the intervals between first and last tests were approximately equal for all children on all tests. The average number of days elapsing between all first and last tests for the 4 motor tests was 83 days for the practice group and 82 days for the control group.

APPARATUS

The moving target test apparatus (fig. 1) was constructed for the learning experiment with young children. The target was moved along on horizontal tracks by means of an electric motor ($\frac{1}{4}$ horse-power direct current) so that the children had to adapt their aim and speed of throwing to this movement. The movements of the target were controlled by a speed reduction drive, pulleys, shafting, and a leather belt which was attached to the back of the target. This operating machinery was mounted upon a channel iron frame 10 feet long and 2 feet wide by means of suitable supports. The shafting and attached pulley on one end was mounted upon a platform which could be moved to adjust the drive belt. The entire apparatus except the target was painted black in order that the white and green target would stand out in relief. The target was started, stopped and reversed by means of a switch placed upon a table 8 feet in

front of the target and to the child's right when facing the apparatus. This location enabled the experimenter to observe to best advantage a child's movements in throwing without interfering with the test. Two rheostat speed controls were also placed upon this table enabling the experimenter to conveniently control the speed and movement of the target. On the basis of preliminary tests it was measured by a tape fastened along the upper guide track.

The target was large—4 feet in diameter—so that nearly all throws struck somewhere on its surface. In spite of this large size and the short distance of the children from the target—5 feet from the center of the running path—the younger children frequently missed entirely. This was usually due to their failure to throw

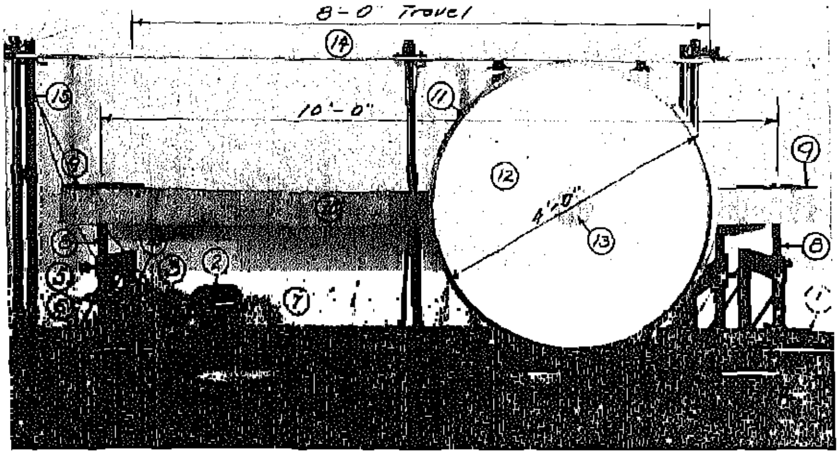

FIG. 1. MOVING TARGET APPARATUS

1, channel iron frame; *2*, one fourth h.p. direct current motor; *3*, coupling; *4*, speed reducer; *5*, worm wheel on speed reducer shaft; *6*, gear on pulley shaft; *7*, adjustable platform; *8*, pulley shafts; *9*, pulleys; *10*, leather belt; *11*, detachable outer ring; *12*, white oil cloth; *13*, green oil cloth; *14*, guide tracks; *15*, pipe frame brackets.

decided to maintain a constant speed of .33 feet a second throughout this experiment. The target slid on rollers that ran in channel iron guides for a distance of 8 feet. A child usually allows a target to move a short distance before throwing at it and the distance of 8 feet was sufficiently large to enable every child to decide to throw. The distance a child allowed the target to move before throwing was high enough. Even the older children occasionally threw wildly.

The target was constructed so that each time the ball struck it a permanent record was made, permitting a more accurate analysis of results than would have been possible otherwise. This was accomplished by placing the following parts of the target in the order named from back to front: heavy board back, copper screen wire

tacked to the board, carbon paper fastened over the screen covered board with the surface toward the front of the target, a record paper cut from newsprint, white oilcloth with smooth surface out, a bull's eye of green oilcloth 7 inches wide glued over the white oilcloth. The oilcloth was fastened to a removable ring bolted to the outer edge of the target by means of 4 wing nuts which could be quickly removed. The record paper was clipped to the oilcloth before putting the ring on the target and quickly replaced for each trial period after removing the ring. Six of these rings were made in order to facilitate record changing. When the ball hit the target a cluster of black dots was made on the record paper. These were clearly distinguishable even when the ball was thrown with little force.

A circle was cut from the center of the target board and attached screen and the detached part suspended in the opening by means of springs. When the ball hit the green oilcloth this suspended center was moved back and rang a bell attached to a frame on the back of the target. This arrangement not only gave the child the green bull's eye at which to throw but gave the added motivation of ringing a bell when the bull's eye was hit.

In order to make the test relatively comparable for all children a platform 6 feet square was used to adjust a child's height to the center of the target. These adjustments were made by means of blocks slipped under the corner of the platform so that the center of the target, 36.5 inches from the floor, would be one inch lower than the child's shoulder height. A few of the children were tall enough to stand on the floor when throwing. The children stood behind a foot board placed parallel with the target and with its center 5 feet from the center of the target's running path. Squash tennis balls 2.25 inches in diameter were used for throwing. A ball of this size was convenient for the children to grasp and easy to grip because of the rough surface.

For convenience in scoring the records a model of the circular target was drawn upon linen drawing cloth and mounted on an easel with a glass back. Concentric circles one inch apart and radial lines 4 degrees apart were drawn upon the model. When the record paper was mounted and a flood light behind the glass turned on, the distance of the center of impact of each throw from the center of the target and its angle were easily determined. This method saved the use of measuring instruments.

PROCEDURE

Every child was shown the apparatus before the tests were begun. After rapport seemed well established the child was brought in front of the target and the experimenter said, "See, this is a big target that runs on these tracks. (E pointed to target and tracks.) You stand here behind this board. (E pointed to the foot board and had the child take a position behind it approximately in the center and facing the target.) I'll start the target and show you how it runs. (The target was run across the eight foot path at the selected speed.)

Now I'll run it back again. (The target was reversed to its starting point.) I want you to throw this ball (the ball was held up so that the child could see it) at the target while it is moving and try to hit the pretty green part, here. (E touched green part.) When you hit the pretty green part a bell will ring like this." (E rang bell once with his finger.) The experimenter then held the ball out before the child at the child's shoulder height and directly in front of him and said, "Try to hit the pretty green part while it is moving and make the bell ring. Now I'll make the target move." (E started target.)

As the ball struck, the target was stopped and the number of the throws in the day's series marked on the spot on the oilcloth. A blunt steel stylus was used so that a mark was not left on the oilcloth but the number was reproduced on the record paper by pressure against the carbon. The experimenter also recorded the distance a child allowed the target to move before throwing by reading from the tape on the upper guide track as well as the hand used in throwing.

On successive throws on the initial test the instructions were, "Remember, try to hit the pretty green part while it is moving and make the bell ring. Now, I'll make the target move." For the first throw on all practice periods after the initial test the instructions were, "See, this is the big target that moves. Try to hit this pretty green part (E touched part indicated) here, while it is moving and make the bell ring like this. (E rang bell with finger.) Now, I'll make the target move." For throws after the first in practice periods the experimenter merely said, "Now, I'll make the target move."

Three preliminary throws and 10 practice throws were given on the initial test, but on all later periods but 10 throws were allowed. At all times the subjects were encouraged in their efforts. In no case, however, was a child given instructions in ways of improving his skill. At the end of each day's practice period the child was praised for his performance. The novelty of the moving target seemed to attract and maintain the interest of every child. Hitting the "green part" and making the bell ring was apparently a real goal. A few of the younger children who could not ring the bell seemed greatly pleased to hit the target or to come near the green part. In no case was any other motivation necessary.

The record blank when completely filled out contained the following information for each throw: the distance the target moved; the hand used in throwing; the manner of throwing; observational notes; the distance from the center that the ball struck; the score, obtained by substracting the number of inches the ball struck off center from 25, (for example, a throw striking five inches from the center of the target was given a score of 20 and a throw striking twenty inches from the center a score of 5); the angle of the spot the ball struck relative to a horizontal axis through the center of the target. The method of scoring follows the usual procedure of giving the better performances the larger scores. The angle values were later analyzed to show whether throws were high or low and to the right or to the left of the center.

TABLE 2

Average scores on moving target test, practice group

SEX	NUMBER	TEST I Av.	TEST I S.D.	TEST 1 Av.	TEST 1 S.D.	TEST 2 Av.	TEST 2 S.D.	TEST 3 Av.	TEST 3 S.D.	TEST 4 Av.	TEST 4 S.D.	TEST 5 Av.	TEST 5 S.D.
3 year age group													
M.	2	6.4		8.8		5.2		4.9		7.8		10.4	
F.	4	3.2		4.6		5.4		4.6		4.8		7.8	
T.	6	4.3	3.8	6.0	3.6	5.3	2.6	4.7	2.0	5.8	2.0	8.7	2.1
4 year age group													
M.	4	11.5		10.2		12.0		10.2		12.0		11.6	
F.	5	11.9		10.6		10.0		10.3		11.0		10.9	
T.	9	11.7	4.7	10.4	3.0	10.9	3.3	10.3	3.9	11.4	2.0	11.2	4.2
5 year age group													
M.	3	18.9		17.4		16.3		16.4		15.6		14.9	
F.	6	11.7		12.2		12.5		13.8		9.4		12.4	
T.	9	14.0	5.3	13.9	3.6	13.7	3.4	14.7	2.0	11.5	3.5	13.2	1.8
6 year age group													
M.	4	17.0		14.6		13.2		14.5		16.5		16.1	
F.	2	13.0		13.0		16.8		16.1		16.4		16.2	
T.	6	15.6	2.2	14.0	3.3	14.4	3.2	15.0	2.2	16.4	2.7	16.2	2.2
All ages													
M.	13	14.0	5.2	13.0	4.2	12.3	4.4	12.1	4.5	13.6	4.8	13.6	3.2
F.	17	9.9	5.2	10.0	4.9	10.6	4.6	12.1	5.3	9.0	4.0	11.3	3.5
T.	30	11.7	5.7	11.3	4.7	11.3	4.6	12.1	5.0	11.3	4.4	12.3	3.8

SEX	NUMBER	TEST 6 Av.	TEST 6 S.D.	TEST 7 Av.	TEST 7 S.D.	TEST 8 Av.	TEST 8 S.D.	TEST E1 Av.	TEST E1 S.D.	TEST E2 Av.	TEST E2 S.D.	AVERAGE OF ALL TESTS
3 year age group												
M.	2	8.0		12.8		9.6		9.9		9.2		8.4
F.	4	7.5		8.0		9.1		8.1		8.8		6.5
T.	6	7.7	3.5	9.6	3.1	9.3	2.7	8.7	1.4	8.9	2.2	7.2
4 year age group												
M.	4	13.2		13.2		12.9		12.6		13.0		12.0
F.	5	8.4		12.2		10.3		12.2		12.8		11.0
T.	9	10.6	4.4	12.7	3.1	11.5	2.5	12.4	2.3	12.9	1.5	11.4

TABLE 2—*Concluded*

SEX	NUMBER	TEST										AVERAGE OF ALL TESTS
		6		7		8		E1		E2		
		Av.	S.D.	Av.	S.D.	Av.	S.D.	Av.	S.D.	Av.	S.D.	
5 year age group												
M.	3	17.0		19.4		17.7		16.5		17.4		17.0
F.	6	11.6		12.0		13.4		12.2		14.6		12.3
T.	9	13.4	3.3	14.5	3.7	14.8	2.8	13.6	2.6	15.5	2.1	13.9
6 year age group												
M.	4	16.1		15.2		16.6		16.6		16.8		15.7
F.	2	16.4		12.5		13.2		15.6		16.2		15.0
T.	6	16.2	1.5	14.3	2.0	15.5	1.9	16.2	1.7	16.6	0.8	15.5
All ages												
M.	13	14.2	3.8	15.2	3.3	14.6	3.3	14.3	3.1	14.6	3.3	13.8
F.	17	10.3	4.2	11.2	3.0	11.5	3.1	11.7	2.8	12.9	2.7	11.0
T.	30	12.0	4.5	12.0	3.6	12.8	3.5	12.8	3.2	13.6	3.3	12.2

RESULTS

Reliability of test

The reliability of the moving target test was computed in the following ways:

1. The sum of the 5 odd numbered throws on the initial test for each child was correlated with the sum of the 5 even numbered throws. The correlation obtained by using the product-moment method, for 60 children in age groups three to six inclusive, was .89 ±.17. When stepped up by the Spearman-Brown prophecy formula the reliability coefficient for the whole test became .94. This coefficient was obviously affected by the age range of the children considered. In order to throw some light on the influence of the age factor, coefficients were computed between the sum of the odds and the sum of the evens as before but first for three and four year old children taken together and then for five and six year old children together. The coefficient obtained for 30 children in age groups three and four combined was .76 ±.05, which stepped up for the whole test became .86. The coefficient obtained for the 30 children in age groups five and six combined was .63 ±.07, which stepped up for the whole test became .78.

2. The average scores for the initial test of 30 children in age groups three to six inclusive were correlated with the average scores on the first practice test, given approximately one week later. The coefficient of reliability obtained by this method was .74 ±.06.

Effects of practice on average scores

The average scores of the 30 children in the practice group for the initial, practice and end tests are given in table 2 for age groups separately and

combined, and for sex groups for each age group and for all ages combined. A score of an individual was the average of the scores made on 10 throws at the target on one day's test period. The scores of individuals

TABLE 3
Average scores on moving target test, control group

SEX	NUMBER	TEST I Av.	TEST I S.D.	TEST E1 Av.	TEST E1 S.D.	TEST E2 Av.	TEST E2 S.D.	AVERAGE OF ALL TESTS
3 year age group								
M.	2	8.7		0.2		9.6		9.2
F.	4	3.8		7.4		7.5		6.3
T.	6	5.4	5.5	8.0	3.5	8.2	2.6	7.2
4 year age group								
M.	4	11.0		12.4		12.0		11.8
F.	5	11.2		11.8		12.5		11.8
T.	9	11.2	5.2	12.1	2.4	12.3	3.1	11.8
5 year age group								
M.	3	15.4		15.1		15.5		15.3
F.	6	11.3		12.4		13.8		12.5
T.	9	12.6	2.6	13.3	2.9	14.4	2.3	13.4
6 year age group								
M.	4	18.4		18.6		10.8		17.9
F.	2	14.8		14.6		15.9		15.1
T.	6	17.2	1.9	17.2	2.2	10.5	1.4	17.0
All ages								
M.	13	14.0	5.3	14.4	4.2	14.1	3.6	14.2
F.	17	9.9	5.1	11.3	3.7	12.2	3.5	11.1
T.	30	11.7	5.6	12.6	4.0	13.0	3.7	12.4

on all tests ranged from 0 to 20.6. Standard deviations are given in table 2 for the practice group for each age group and for all ages combined, and for total sex groups. Table 3 is similar to table 2 and gives the data for the control group. Figure 2 shows the average scores for the practice group as compared with the control group. It also shows separate curves for the practice group boys, and the control group boys, the practice group girls, and the control group girls.

Total groups. Tables 2 and 3 and figure 2 show that both the practice and control groups made small gains in average scores from initial to final tests and that the gain of the practice group was slightly larger than the gain of the control group. The average of each group on the initial test was 11.7. The final average of the practice group was 13.6, a gain of 1.9; the final average of the control group was 13.0, a gain of 1.3. The practice group thus gained 0.6 more than the control.

The formula for the standard error of a difference between correlated measures,

$$\gamma \text{ Diff.} = \sqrt{\gamma^2 \text{Av. } 1 - \gamma^2 \text{Av. } 2 - 2\, r_{12}\, \gamma \text{ Av. } 1\, \gamma \text{ Av. } 2},$$

was used to determine the statistical significance of the gains of the practice and control groups. By this formula the gain of the practice group was 1.9 with a standard error of 0.60 and the gain of the control group 1.3 with a standard error of 0.73. The gain of the practice group was thus 3.2 times the standard error and may be considered significant. The gain of the control group was only 1.8 times the standard error—not statistically significant.

The standard error of the difference in gains of the practice and control groups computed from the formula

$$\gamma \text{ Diff. in gains} = \sqrt{\gamma^2 \text{gain } 1 + \gamma^2 \text{gain } 2}$$

was 0.95. The obtained difference of 0.6 is not therefore significant by the usual criterion that the obtained difference must be three times its standard error in order to be considered

The average score for all tests combined was 12.2 for the practice group and 12.4 for the control group. This lower average for the practice group was due to the fact that their average

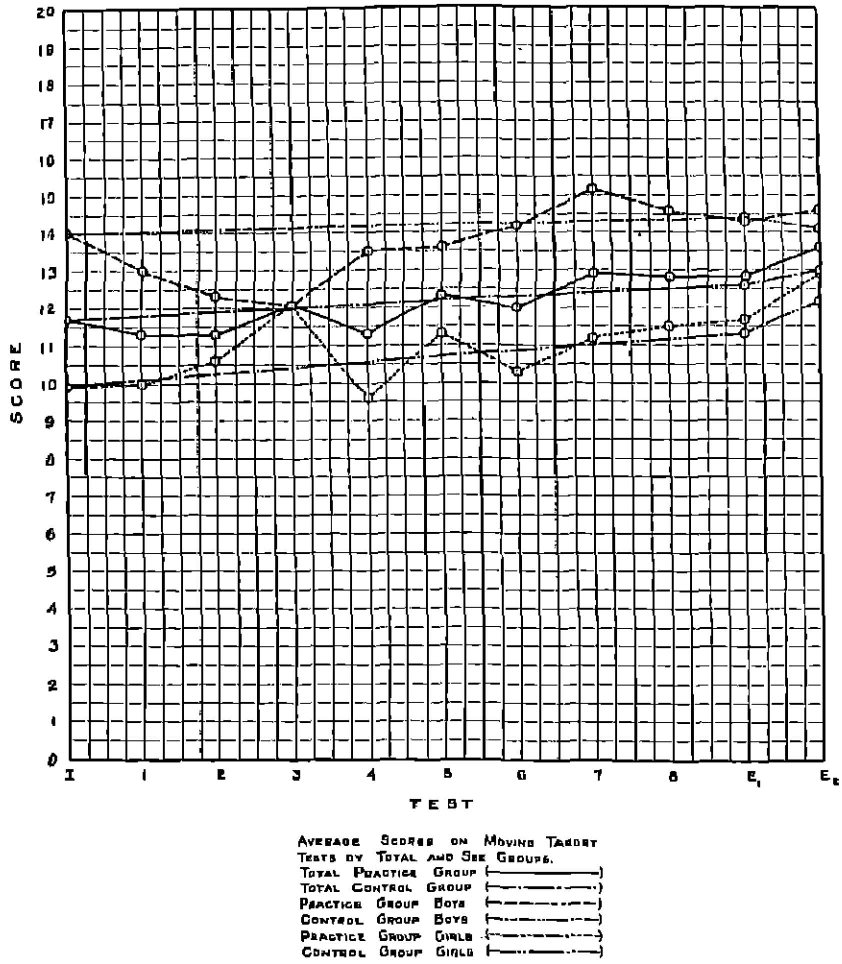

FIG. 2

statistically significant. The difference in the gains of the 2 groups on the first end test also is not significant because the obtained difference in gains was but 0.2.

fell below the initial test average on practice tests 1, 2 and 4, as indicated by figure 2. The individual records show that 17 practice group children gained in scores from the initial to the

final test while 13 lost; 16 control group children gained, 13 lost and 1 did not change.

Sex groups. The practice and control group girls, all ages combined, each had an initial test average of 9.9. On the final test the practice group gained 3.0 and the control group 2.3, a difference in gains of 0.7 in favor of the practice group. The difference on the first end test was but 0.4. The curve for the practice group fluctuates from test to test. It is difficult to account for the high peak on test 3 when an average of 12.1 was made, an average not made again until the final test. The drop to an average of 9.6 on test 4 is due to the drop of the five-year-old girls. Five of the 6 girls in this group made lower scores than on test 3 but the only large drop was in the case of one child who dropped from 19.3 to 8.3, due to the adoption of an inhibited style of throwing.

The initial test scores of all boys of the practice and control groups was 14.0 for each group. On the final test the practice group gained 0.6 and the control 0.1, a difference in gains of 0.5 in favor of the practice group. On the first end test the control group surpassed the practice group by 0.1. On test 3, which was a high peak for the girls, the boys' average of 12.1 was their lowest average score. This was the same average as that of the girls for the same test. The highest average, 15.2, was made by the boys on test 7.

Comparing the average scores of the boys and girls for all tests combined given in tables 2 and 3, it is seen that the boys surpassed the girls at each of the four age levels in both the practice and control groups except in the four-year-old control group in which the averages of the boys and girls were the same. These consistent differences indicate that the boys excelled on this test. The evidence that the boys excelled is even stronger when the average age in months for each age group is considered. In each age group of the practice and control groups, except the five-year controls, the boys were 0.7 to 4.5 months younger.

Age groups. Figure 3 shows the averages by age groups, for the practice and control subjects. The three-year age groups of the practice and control groups made the lowest average scores on all tests but made the largest gains from initial to final tests. The gains for each age group were as follows: three-year practice group 4.6, control, 2.8; four-year practice group 1.2, control, 1.1; five-year practice group 1.5, control, 1.8; six-year practice group 1.0, control, −0.7. Thus the three, four and six-year old practice groups exceeded the control groups whereas the opposite was the case with the five-year-old group.

Comparing the age group average scores on all tests combined in tables 2 and 3 it is seen that the average of the three-year-old practice and control groups was the same, the control excelled 0.4 in the four-year group, the practice group, 0.5 in the five-year group, and the control group, 1.5 in the six-year group. The lower averages of the practice groups were due to test periods in which the averages fell below the initial and final test averages.

The combined gain of the three and four-year-old practice and control

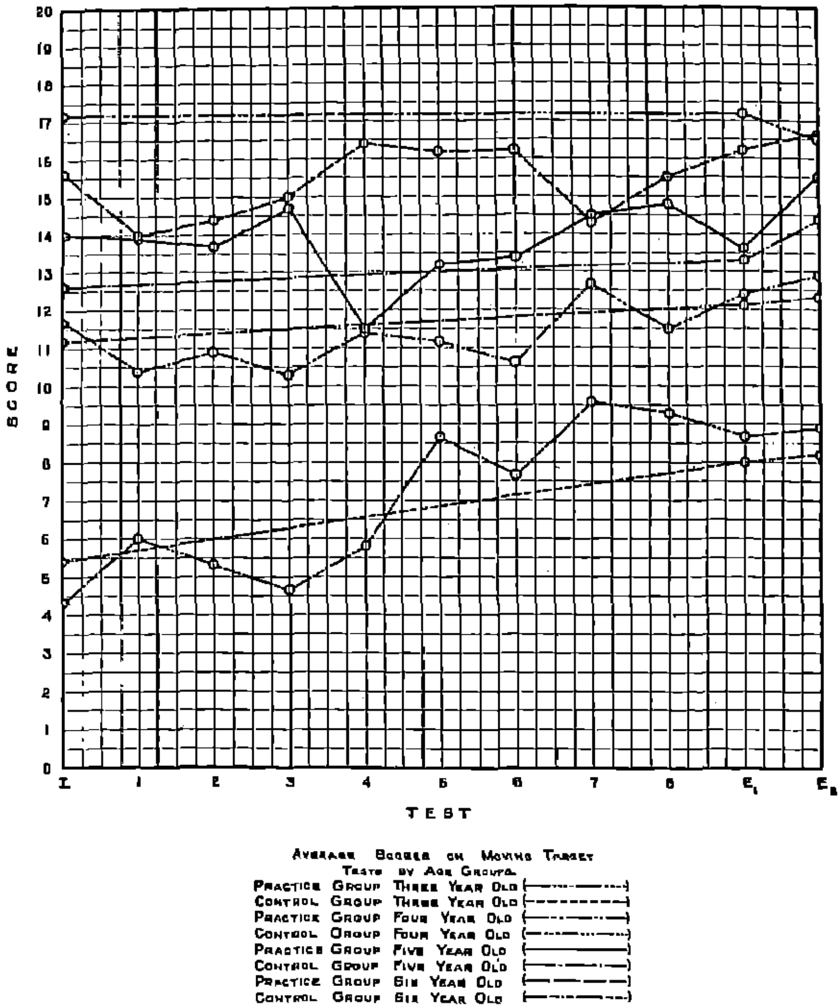

FIG. 3

groups was 2.22 with a standard error of 0.88. The gain of the five and six-year-olds was 1.02 with a standard error of 0.56. The difference in gain between the 2 groups was 1.2. The standard error of 1.04 indicates that the difference is not statistically significant.

Variability of groups

Coefficients of variability were high for both the practice and control groups due to large standard deviations. There was a consistent tendency, however, for the coefficients to

become smaller on later tests, showing that the scores of individuals in the groups became more closely bunched. No significant difference in this tendency existed between the practice and the control groups.

The coefficient of correlation between the gains for individual scores from the initial to the final tests and the scores on the initial test was $-.78 \pm .03$. This also indicates that the scores of the individuals in the group were becoming more closely bunched.

This tendency toward bunching seems to have been due to the fact that children scoring high on the initial test made small gains on the final test as compared with children scoring low on the initial test. An examination of individual records corroborates this. For the practice and control groups combined 9 children in the upper half on the initial test gained on the final test while 21 made lower scores; 24 in the lower half on the initial test gained, 5 lost and 1 did not change. This tendency is probably due in part to the fact that the units of improvement on the scale of 0 to 25 were not equal in difficulty of attainment.

Practice effects within test periods

In order to determine the effects of practice within a test period the average scores for each of the 10 trials of the test period were computed. Table 4 gives the results for the practice and control groups separately.

An examination of the averages in table 4 discloses that the average scores of the sixth to the tenth throws are slightly higher than the first to the fifth. The average of the first five throws of the practice and control groups combined is 11.9 and of the last five throws 12.6, an advantage of 0.7 for the last five throws.

Another indication that there was some practice effect within each practice period is shown by the fact that the bell was rung 102 times out of 217 on the first five throws and 115 on the last five throws.

TABLE 4

Average score by trials within a practice period for moving target test

Throw in series										
1	2	3	4	5	6	7	8	9	10	All
Practice group										
11.8	11.3	11.7	11.8	12.3	12.0	12.8	12.2	12.4	13.1	12.1
Control group										
11.9	12.6	11.2	13.1	12.0	11.7	13.1	13.0	12.8	13.0	12.4

Practice effects on elimination of errors

For the practice group 76 per cent of all throws were below the center of the target on the initial test and 62 per cent on the final test, a reduction of 14 per cent. For the control group 69 per cent of the throws were low on the

initial test and 67 per cent on the final test, a reduction of 2 per cent. There is some evidence of a greater tendency for the practice than for the control group to eliminate the low throws. However, this did not bring about a significant difference in the gains in scores of the 2 groups.

For the practice group 67 per cent of all throws on the initial test were to the left and 61 per cent on the final test, a reduction of 6 per cent. For the control group 69 per cent were to the left on the initial test and 62 per cent on the final test, a reduction of 7 per cent. There was thus a slight tendency for both groups to correct their throws to the left.

Distance target moved

The children stood facing the center of the 96 inch path through which the target might run so that it would seem that the target would be easier to hit when approximately in the center of its running path. This would be at the 48 inch mark. However, the children did not let the target move 48 inches before throwing. The average of the practice group on the initial test was 19.4 inches and on the final test 19.8; of the control, 20.4 on the initial test and 24.2 on the final test. There is no evidence that practice had any great effect on the distance the target was allowed to move.

Relation of success to other trials

In order to determine the relationship of throws that rang the bell to throws immediately preceding or following, the data were analyzed as follows: The average of all throws immediately preceding a throw which rang the bell was computed for all trials in the day's series for the children in the practice and control groups combined. Similar averages were computed for all throws immediately following the ringing of the bell. The averages of all throws not ringing a bell and not just preceding or following a throw which rang a bell was 13.5. The average of all throws immediately preceding the ringing of a bell was 14.6 and the average of all throws immediately following the ringing of a bell was 15.2. The difference between the average scores of the throws not ringing a bell or not immediately preceding or following a throw which rang a bell, and the average of the scores immediately preceding the ringing of a bell was 1.1 with a standard error of 0.47. The difference between the average scores of throws not ringing a bell or not immediately preceding or following the ringing of a bell, and the average of scores immediately following the ringing of a bell was 1.7 with a standard error of 0.41. Both obtained differences are large in relation to their standard errors and are probably not chance differences.

There is evidence, then, that the throw striking a bell was affected by the throws immediately preceding it and in turn influenced the throw immediately following it. The throw ringing the bell was probably affected by the practice preceding it and especially by the practice on the throw immediately preceding. In like manner the throw ringing the bell probably had its greatest carry-over to the throw immediately following. This may have been due partly to the factor of

motivation which would probably function best immediately after throws which either hit the bell or came very close to it.

Manner of throwing

Children differed strikingly in their styles of throwing. Each child also often varied his style in various ways. Some of the variations were as follows: hand used; manner of holding ball; movement of parts of the body such as the hands, arms, shoulders, trunk, legs and feet; force of throw; position of the child.

In both the practice and control groups 96 per cent of all throws were with the right hand. A few children of all ages occasionally threw with the left hand but no child threw exclusively in this way. One boy in the three-year-old practice group and one girl in the five-year-old control group were the only children who made at least half of their throws with the left hand.

Records were kept whether throws were overhand, underhand, toss, or miscellaneous. A throw was considered overhand if the hand was brought forward above a plane horizontal with the elbow; below this plane, it was considered an underhanded throw unless the arm was not bent in delivering the ball, which was considered a toss. Miscellaneous throws included peculiar styles of delivery such as pushing the ball from the waist with both hands and throwing from the waist outward. The per cent of the various styles of throwing for the practice and control groups combined was as follows:

SEX	CASE	THROWS	OVERHAND	UNDERHAND	TOSS	MISCELLANEOUS
Girls..........	34	2380	88.8	3.4	6.6	1.2
Boys..........	26	1820	87.1	11.9	0.5	0.5
Total.......	60	4200	88.0	8.1	4.0	0.9

It is seen that 88 per cent of the throwing was overhanded.

Relation to intelligence

The correlation of the scores on the initial test on the moving target with mental age for 59 children ages three to six was .56 ±.09. When chronological age was partialed out the correlation was reduced to .05 ±.09. Apparently skill in throwing at the moving target had little relation to intelligence as measured by tests.

SUMMARY

The purpose of this investigation was to study some aspects of the development of motor coordination in young children. The objective was to discover the effects of systematic well motivated practice upon the ability of young children to hit a moving target with a ball. Two groups of children of 30 each, ages two and one-half years to six and one-half years, were equated upon the basis of their initial performance on a moving target test. The practice group repeated the test once a week for eight weeks. At the end of this period the practice and control groups repeated the test twice on successive weeks. Three other motor tests were given, once at the

beginning and again at the end of the experiment.

From an analysis of the data for composite groups on the moving target test, the following are some of the more pertinent results:

1. Both the practice and the control groups made gains in average scores from the initial to the final tests. The gain of the practice group was larger than the control group but the difference in gains was not statistically significant.

2. In the practice group 17 children gained and 13 lost in scores from the initial to the final test. In the control group 16 gained, 13 lost and 1 did not change.

3. The boys made larger average scores than the girls in the different age groups.

4. Younger children made lower average scores on the test but made larger gains from the initial to the final test.

5. The variability of the scores of both the practice and the control groups decreased greatly from the initial to the final tests.

6. There was evidence of practice effects within each test period as the average of the last five throws was higher than the average of the first five in the series of 10 throws.

7. Both the practice and control groups tended to correct their throws when they were too low but not when they were too far to the left.

8. Practice did not affect the distance the children allowed the target to move before throwing.

9. The averages of scores on throws immediately preceding or following a throw which rang a bell were higher than the average of the scores for other throws in the series.

10. Ninety-six per cent of all throws were with the right hand.

11. Eighty-eight per cent of all throws were overhanded.

12. The correlation of the initial scores and mental age, with chronological age partialed out, was $.05 \pm .09$.

Two comparable groups of children increased in skill in hitting a moving target with a ball over a period of three months. However, the group which was given specific practice throughout this period of time did not improve significantly more than the group which was not given practice other than on the initial and final tests. These results indicate that the improvement in skill did not result primarily from specific practice but from other factors such as structural maturation and general practice which had a direct bearing on the specific skill.

No attempt was made to differentiate the relative effects of each of the factors other than specific practice on the increase in skill. However, in the present tendency to emphasize the rôle of structural maturation in learning we should not overlook the importance of practice on the relatively simpler skills which are utilized in performing a complex skill. The children employed in this study practiced many coordinations of body, eye, arm, hand and leg movements in their ordinary daily activities which were utilized in the complex skill of hitting the moving target.

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The Galvanic Skin Reflex in Infancy

HAROLD ELLIS JONES

According to investigations by Peiper (2), the galvanic skin reflex in human infants is undeveloped until the age of about twelve months. Its absence in early infancy cannot be due to immaturity in the effectors, for the cutaneous organs concerned in the reflex are apparently anatomically and functionally well developed. Nor can it be assigned to a deficiency in the receptors nor in the centripetal pathways, for skeletal muscle reactions can be elicited by the same stimuli which are ineffective in producing a G.S.R. Peiper finds his results consonant with the theory of vagus dominance in infants, and concludes that the reflex arcs concerned in the G.S.R. are incomplete either centrally or in the efferent thoracico-lumbar pathway.

Results[1] obtained by the writer with each of 8 infants, three to eleven months of age, are at variance with those reported by Peiper, and appear to demand a reconsideration of his theory. The galvanometer used in the present experiment was a simple moving coil instrument (D'Arsonval, manufactured by E. Roger, Paris) with a Wechsler (6) circuit. The galvanometer was connected across a Wheatstone Bridge, the subject and a milliameter being in series in the fourth arm of the Bridge. With infants it is of course impossible to use cup electrodes, and as a substitute a bandage type of electrode was employed, consisting of two pieces of silver foil, 2 cm. square, which were soldered to the wires leading from the fourth arm of the Wheatstone Bridge. In order to prevent battery action at the solder junctions, these were covered by a flexible and moisture-proof wax preparation. The foil electrodes were sewn into pockets of soft fabric, covered with kaolin and saturated with normal saline; the moist clay forms a paste which adheres to the skin, and avoids resistance fluctuations from changes in the skin contact.

The usual procedure was to bring the child into the laboratory at 8:00 a.m., which proved to be the most favorable time for observation in infants of this age; usable records, however, were also obtained in the later morning and in mid-afternoon. The electrodes were attached to the right foot, one to the sole under the instep and the other to the calf of the leg. The child was placed in a comfortable position on a couch, out of sight of the experimenter and of the apparatus employed to produce stimuli and to record responses. A reflection system focused a beam of light from the galvanometer mirror upon a zero position on a kymograph (fig. 1). Current was now passed through the potentiometer until a standard reading of 0.1 milliam-

[1] An investigation made at the Institute of child Welfare, University of California.

peres was obtained on the milliameter in series with the subject; a deflection of the light occurred, of course, at the same time. The Wheatstone Bridge was adjusted to bring the deflection back to zero, and the subject's initial resistance could then be read from the dials. For the remainder of the experiment, the milliameter reading was maintained as constant as possible at .05 m.a. A standard schedule of stimuli was used, including visual, auditory, thermal, and electro-tactual stimuli, their duration and intensity being controlled by a system of switches and rheostats. The recording drum consisted of a continuous roll kymograph, calibrated for seconds, and moving at a constant rate of six inches a minute. The resistance line was traced by hand instead of photographically, although in some cases photographic records were also obtained. The manual method has the advantage

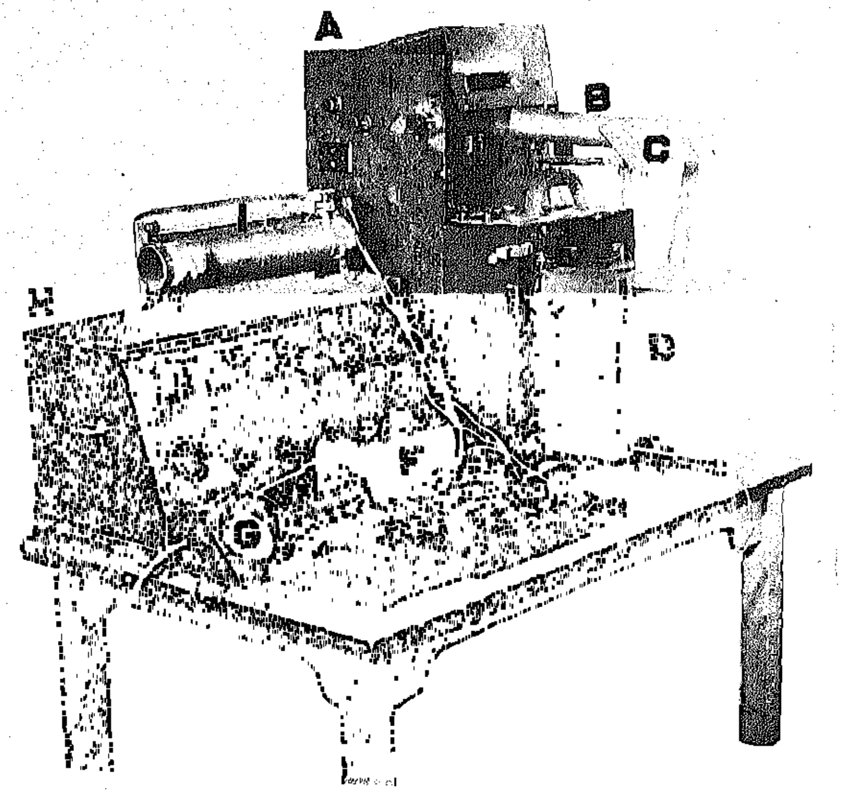

FIG. 1

A, galvanometer housing; *B*, light tube; *C*, stationary mirror; *D*, kymograph; *E*, Wheatstone Bridge; *F*, potentiometer; *G*, milliameter, *H*, stimulus control box; *I*, supplementary rheostat for Bridge.

of keeping the experimenter closely in touch with the subject's reactions, and makes it possible to note down accessory records, in symbol form, at the appropriate places beside the resistance line. In the case of responses which have such a slow latent time as the G.S.R. (one and one-half to three or more seconds) even an untrained person finds no difficulty in accurately following the resistance line. In order that the infant's overt behavior might be compared with the galvanometric data, a second observer took a detailed record of bodily movements, changes in facial expression, flushing, overt respiratory changes, and vocalizations.

Records were obtained for 60 experimental periods of about thirty minutes each. In the case of 1 infant, repeated observations were made each week from her sixth to her ninth month.

No difficulty was found in obtaining galvanic responses from infants even as young as three months. The most effective form of stimulation was electro-tactual, through electrodes attached to the arm or the left leg. In administering the current an attempt was made to adjust the intensity (through a rheostat introduced into the secondary circuit of a Porter inductorium) so that it would be strong enough to produce a G.S.R., but too weak to result in crying or overt movements. This differentiation proved to be readily possible, although with some subjects it was necessary to guard against summative effects of stimulation. Next to mild pain stimuli, the most effective agents were loud sounds. All of the subjects showed a marked response upon the first presentation of a bell, buzzer or loud clang. Their overt reactions, however, were less consistent, and in several cases bodily startle reactions to loud sounds were never shown except when the infant was falling asleep. G.S.R.'s were obtained to the removal of the bottle when nursing, and to situations involving a sudden withdrawal of support. They were never elicited by visual stimuli (except after conditioning) (1), by conditions involving relief, nor by any forms of stimulation which would ordinarily be described as "pleasant."

In comparing the results from infants with those obtained for 45 adults and for 40 nursery school children,[2] under similar instrumental and stimulation conditions, the following points may be noted:

1. In its basic characteristics, the G.S.R. is similar to that found in older subjects. This applies to the phenomena of (a) latency (typically from two to three seconds) (b) the parameter of deflection (fig. 2) (c) specific negative adaptation (except for definitely nocive stimuli), and (d) specific recovery after an interval.

2. The incidental phenomena are similar: (a) the curve of rest (a stabilization process at the beginning of the experiment, involving usually a steady reduction in resistance (5), (b) the Vorausschlugphänomen (5) (an initial small reverse deflection sometimes occurring with intense stimuli) (c) the occurrence of spontaneous or secondary responses after intense stimulation ("Doppelschwankungen")

[2] The results for the nursery school children are in process of preparation. The data for adults have been reported, in part (7).

and (d) characteristic resistance changes in respiratory reactions, as in sighing. An inverse relationship was shown to overt movement; stimuli which produced an inhibition of arm-leg movements frequently gave a marked G.S.R., while stimuli of an intensity to produce crying or thrashing movements were often followed by a diminution or extinction of the G.S.R. This is in essential agreement with results for adults, reported by Prideaux (3). In certain cases, spurious resistance changes were sometimes effected by pressing the foot on the bed or against the other foot and thus altering the electrode contact. Deflections due to this cause could readily be recognized, not only through their concomitance with activity, but also through their abruptness and rapidity. In rare cases it became necessary to immobilize the leg by holding it just below the knee.

3. The initial resistance tends to be lower in infants than in adults. Only about 5 per cent of the adults showed resistances as low as 8000-10000 ohms, which was average for the infants.

4. No change in resistance was noted in relation to sleep or waking. This is in disagreement with Richter's (4) report to the effect that a rise in resistance occurs in adults during sleep; the disagreement probably cannot be accounted for in terms of the points of attachment of the electrodes. On 8 different occasions characteristic psychogalvanic responses (to sounds) were obtained during sleep; these were usually, but not always, of a diminished magnitude.

5. As in adults, the most effective stimuli are those which involve "startle," or "frustration," and which are commonly regarded as associated with the emotional states of fear and anger. For these stimuli, the intensity threshold is higher than is usually found for adults. It is possible that Peiper's failure to obtain the G.S.R. in infants was due to the use of stimuli of too weak intensity; his record of procedure is too meager to permit judgment on this point. Correlated with the fact of high threshold, is the fact that the magnitude of deflection tends to be smaller than under similar conditions with adults.

These results unquestionably demonstrate the functional completeness of the arcs involved in the galvanic skin reflex, at least as early as three

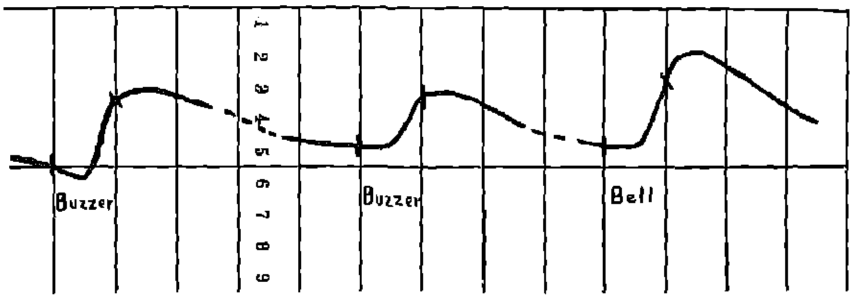

FIG. 2

months of age. The fact that the G.S.R. in infants is smaller and less easily aroused than in older children, can no doubt be explained in terms of the relationship between overt and visceral expression. If this relationship were always positive, our instrumental records would show an increase in visceral activity accompanying the more external signs of disturbance. In so far as the galvanometer, however, may be taken as indicating visceral changes, our evidence points in another direction. Children who are the most ready to cry are frequently the least reactive on the galvanometer; in such subjects, when G.S.R.'s do occur, they may be diminished or eliminated by an intensification of the stimuli, with resulting crying or bodily movement. The quick transition in emotional tone, so often exhibited in young children, is probably a further indication of the "surface" character of their emotions, and of a lack of persisting visceral reinforcement. In older children the increase of inhibition and of apparent emotional control may imply (with reference to certain stimuli) merely a shift from outer to inner patterns of response. When a direct outward release is blocked, the condition of the organism appears to be favorable to a heightened visceral discharge, one expression of which is provided by the galvanic reflex. Thus the characteristic features of "infantile" emotional behavior may be related to the stage of development of those mechanisms which are concerned in determining the proportions of somatic and of visceral discharge.

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The Orientation of Plane Figures as a Factor in Their Perception by Children

CHARLOTTE RICE

HISTORICAL

IF ONE were to limit a review of the field of perception to material which concerns the specific problem in hand, i.e., the orientation of plane figures as a factor in their perception by young children, practically nothing would be cited except the following general statement made by Stern in describing the reaction of his own children to pictures:

> It has often been observed that it seems to make little difference to small children whether a picture is put before them right way up or upside down. . . . The older the child, the less of this indifference to the position of the picture; and in any case it varies very much with individuals, for there are children in whom it has not been observed at all. (19)

He cites careful observations of this indifference in his own children at the ages of one year seven and one-half months and three years five months, and explains the recognition and production of pictures upside down by the supposition that the idea of form and the idea of position are two distinct psychic functions, the second of which is only developed by a somewhat slow process of learning. To this report may be added the proverbial surprise of parents upon discovering that a child's enjoyment and comprehension of a picture is in no way altered by the position in which he sees it.

But such data merely serve to indicate the existence, without limiting the ages, of a period in the life of the child when the position of a picture in no way affects his attitude toward it, followed by a period in which the orientation, when normal, helps, and when abnormal, hinders the comprehension and appreciation of the material presented to vision. Such a limitation was the purpose of the experiment here presented.

The three fields of imitative drawing, of recognition of similar forms, and of color and form preference in perception encroach so closely upon this one, however, that a preliminary review of the work done in them will be of sufficient interest to be worth while. Also more general deductions concerning the development of visual perception in children are constantly being made in other connections, such as the conclusion by Oppenheim (18) that a child comes to associate visual impressions with the proper relations of the object in space only in the most gradual way, and that this difficulty together with a limited power of accurate observation is bound to make his reports of events unreliable. Cramaussel (4), in evaluating reports from

children three to six and one-half years of age concerning what they see on a postage stamp, concludes that as age advances, the specific takes the place of the vague and general in the response, confusion gives place to well defined limits, and enumeration gives way first to description and then to analysis. Such generalizations reflect the obvious fact that the development of perception is a gradual process, without limiting the steps involved. For the latter we must turn to the more specific experimental work.

The responses in imitative drawing are peculiarly limited. Always the child tends to draw what he knows rather than what he sees. For spontaneous drawing this is quite satisfactory, because he is under no obligation to finish the picture he starts. But for imitative drawing, which is *rarely attempted at early ages except* under experimental conditions, this tendency and the child's ready suggestibility make it difficult for him to persist in the task until it is completed, and frequently failure to copy even simple forms may go with a considerable degree of creative ability in spontaneous drawing.

In 1911, Van Gennep (22) reported unrecognizable attempts on the part of his 5 year old daughter to copy outline drawings of simple objects and printed letters. The pictures, having more meaning to the child, were more like the copies than the letters, though the latter were simpler of execution.

Huth (11), in 1914, experimenting with 37 kindergarten pupils averaging four and one-half years of age, to see whether they were ready to receive instruction in writing, concluded that children of this age show little ability to copy meaningless combinations of lines. Work of more recent date on a comparable group of subjects was done by Gates and Taylor (8) in 1923, and Hertzberg (10) in 1926, on methods of teaching beginners to write. In these studies it was found that the method of copying directly from the model was both harder to learn and less interesting to the child than any of the various methods of tracing used.

Another section of this field is that of mirror writing, an anomaly which had been associated up until about 1902 almost entirely with cases of mental disorder or paralysis affecting normal motor coördination. But in 1909, Stern (20) reported mirror drawing and writing as a natural phenomenon in young children especially in imitative drawing. When, *according to Stern, at four years*, children begin to outgrow scrawling and make real forms, there appears, at first, little perception of position. The frequent easy use of the left hand at this period is often accompanied by mirror writing, and the tendency to watch the progress of an older brother or sister from across the writing table, and to imitate the observed motions, is a very frequent source of the development of reversed writing and drawing. E. Sz. at five years, copied from his brother in this manner, using his left hand, and learned his letters so well that he could write anything that was spelled to him. Later, he began suddenly and apparently without external urging to form his letters in the normal positions and order, still using his left hand, and finally, just as spontaneously, and

before he had reached the age of seven, he shifted from the left to the right hand, still maintaining the normal position and order of the letters. Stern cites similar cases, reported by Ballet, Degallier, Kerschensteiner, Maurer and Albien.

Two instances of a strikingly similar nature occurred in the Child Institute of the Johns Hopkins University last year. In one case, both the right and left hand were used in drawing, and the motions in the left hand were nothing less than a right to left reversal of those in the right. In the other case, the right hand alone was used, but many of the letters were formed backwards. In neither case did the child see anything exceptional in his result. Indeed, many adults who have not been trained to care in writing and printing show reversals of this nature,—as a hasty survey of "no trespassing" signs in any rural section of the country will show.

In 1913, Paula Meyer (17), in various experiments, under different conditions, but all designed to show a comparison between the child and the adult in the ability to reproduce figures from memory, found a consistent tendency for a certain percentage of reversal and inversion. The children used in the experiments were seven years old or older, and they showed a 51 per cent tendency to neglect orientation, as against a 39 per cent tendency on the part of the adults.

On the abnormal side, Downey (6) describes a case in which mirror writing, persisting into adult life was associated with general motor disorientation, and Hornig (7) finds dislocations in writing and drawing combined with speech defects in elementary school children. Other cases in which the phenomenon is found along with pathological conditions are described by Abt (1) and Laprade (16).

It is evident from the above that orientation of the figure or letter seems to mean very little to a child who is just beginning to imitate in his drawing and writing. Whether a similar condition occurs generally with reference to a child's comparison of objects with regard to their similarity or difference, will be brought out, it is hoped, by the present experiment.

In the field of recognition of similar forms, much seems to depend at the outset on the child's ability to comprehend the significance of the terms "like" and "different." The results of an experiment by Jones (12) in 1925 seem to indicate that in general the judgment of difference develops sooner than that of similarity. In dealing with geometrical forms or familiar outline figures, the complication of language development is to a large extent removed, but the importance of the comprehension of these two terms remains.

In 1913, Koch (14) employing a simplified form of Gruenbaum's (9) method found that the performance scores for the recognition of like elements in two figures increase from 22 per cent perfect to 64 per cent perfect among the boys from the first grade to the eighth, and from 25 per cent perfect to 63 per cent perfect among the girls, about 60 per cent of this gain occurring during the first four grades. When the recognition and localization of the unlike figures is included, the

girls reach in each grade, only about two-thirds the ability of the boys. In 1920, von Kuenburg (15) extended this work to children between the ages of three years six months and six years six months. Her figures substantiate those of Koch to a large extent.

In 1013 and 1914, in experiments devised to demonstrate the relative preference for form or color in matching figures, Katz (13) and Descoudres (5), conluded that the perception of form develops later than that of color. But when Buehler (3) and von Kuenburg (15) altered the conditions of the problem to include the processes of building with blocks, or fitting covers on boxes, they found that the choice according to form was preferred.

In 1927, Tobie (21) concluded from a combination and revision of these experiments that up to the age of three years, eight months, there appears a phase of early development in which the reaction to form or color is dependent not on the central conditioning, but on the intensity and vividness of the factors themselves. Above this, the child is conditioned on constitutional grounds to prefer color, gradually shifting over to form preference at about five years.

In 1929, Brian and Goodenough (2), repeating and modifying the Descoudres experiment, found form preference at all times up to the age of eight years except between the ages of three and six years, when color gradually rose to a peak and subsided again.

From the above it is evident that the development of form perception is gradually beginning to appear significant about the age of five years. While none of the experimenters have defined the term perception—many of them avoiding it completely—there seems to be a general consensus of opinion that it refers to a certain type of reaction to sensory stimuli distinguished by a more or less well developed ability to discriminate—perception and discrimination growing in a parallel course. It is in such a sense that the term will be used in the material here presented.

It was in the course of a test for the discriminatory recognition of the diamond among a number of similar and dissimilar geometrical figures that the the unexpected fact was disclosed that the two oldest children of the group refused to accept as the same, two figures which were identical except for their orientation in place on the page—the long axis of one diamond being horizontal, and of the other being vertical. No such refusal, or even hesitation was noticed on the part of any other child in the group.

Since the two children in question were at the very top of the age range of the group, being five years and one month and five years and three months respectively, it was logical to surmise that they might well be on the lower limit of an age range in which the orientation of a figure entered as a positive factor in its recognition and hence in its perception. Further preliminary study on another kindergarten group the same year, in which the age range was nearly identical, led to corroboration of the previous data. The demand for a test which would determine the possible existence and limits of such an age range was obvious, and so was developed the final form of the experiment herein to be de-

scribed, as a test by which to determine, if possible, the age when a child either will, negatively, refuse to recognize "sameness" in two figures which are identical, but not in the same position on the page, or will, positively, indicate by some word or action that they would be the same if one or the other were turned part way around.

DESCRIPTION OF EXPERIMENT

A problem in visual perception is almost bound to encroach somewhat upon kinaesthetic perception, not only because of the eye movements accompanying most acts of observation, but also, in the matter of certain grosser movements of different parts of the body—noticeably the hands. The latter is especially true when the aim of the perception is later recognition or reproduction. For this reason it was decided to combine with the test of form perception 2 other types of test; one, a test of the development of motor control in handling a pencil, and the other a test presumably of the ability to combine motor control and perception in the copying of a simple line figure. By showing the relation between the degree of development of the perception of form and the ability to copy a figure on the one hand, and motor ability and the ability to copy a figure on the other, it was hoped incidentally to throw some light on the general question of the relative importance of training in perception and in motor control for the accurate pictorial representation of form.

The complete test consists of an array of 5 individual tests, 2 forms of the copying test, 2 of the perception test, and 1 of the motor control test, which are given in two test periods two weeks apart in time. During the first test period the child is presented with 3 of the 5 tests, 2 of the copying tests and 1 of the perception tests. Two weeks later, during the second test period, the child is presented with the other 2 tests, the second perception test and the test of motor control. A detailed account of the form of the tests and the experimental procedure follows.

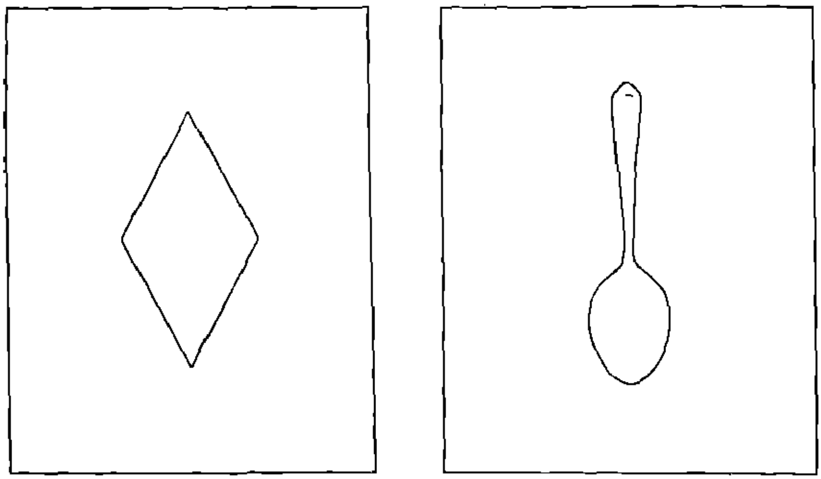
Copying Test: Drawing of Diamond from Visible Model

The materials for this test consist of a single white card 4 by 5 inches, on which is a black ink drawing of a diamond $2\frac{3}{4}$ inches (long axis) by $1\frac{1}{2}$ inches (short axis) (fig. 1, *a*). This card serves as a model in both the copying tests and in the tests of form perception. Slips of paper torn from pads 3 by 5 inches seem to furnish the most convenient form for maintaining the record of performance. The child is seated comfortably across the table from the experimenter and is shown the model card in the horizontal position with the instruction: "Do you see this (pointing to drawing, but being careful not to trace)? See what a nice picture you can draw for me that will look just like this." At the same time he is presented with a slip of paper, also in the horizontal position, and a pencil. Time is taken with a stop watch from the moment he begins to draw until the pencil is lifted after the last line. No matter what the result of the attempt, praise is given in the simple form "That's fine." When the child has finished, the experimenter takes the copy and

records on the same slip the time taken for the drawing. In cases where the production is a mere scribble, the time is taken between the beginning of drawing, and the first pause in operations or wandering of attention sufficient for the examiner to terminate matters with "That's fine" without appearing to interrupt an apparently well unified activity. This same procedure is then applied, with the model and paper both presented in the vertical position. Occasionally, if the second copy is better than the first, the form of praise is changed to "That's the best one yet." Frequently it is found that when the child starts to draw, especially in the cases of the younger ones, the lines suggest something other than the form he has been told to copy, and he announces that he will make you such-and-such a thing. The instructions are then repeated: "But make something that looks just as much like this as you can (pointing again to the model)." If the child says he can't, he is encouraged to try as hard as he can anyway by some such admonition as: "Oh, but everybody tries," or "But try just the best you can, anyway."

Test of Discriminative Perception: Perception of Diamonds—Vertical and Horizontal Presentation

The materials for this test consist of the model card described in the copying test, and 4 cards $8\frac{1}{2}$ by 11 inches, each containing a variety of figures arranged as in figures 2 to 5 inclusive.



a. Perception of Diamond Test *b.* Perception of Spoon Test

FIG. 1. MODEL CARDS

The diamond model is placed in front of the subject in the vertical position, and the following directions are given: "Now, I have a card here with some pictures on it, and one of them looks just like this (pointing to the model). I want you to see how quickly you can put your finger on a picture on this card (pointing to

the card) which looks just like this (pointing again to the model.)" Then while laying the first card in front of the subject—"Where is one that looks just like it?" The stop watch is started at the moment the card is placed in front of the subject, and is stopped the minute the finger comes to rest on the first figure indicated. No matter what figure is pointed to, the examiner's response is simply, "All right." Occasionally, the child realizes immediately that the figure pointed to is not the correct one and points again, saying something such as "No, this." In such a case, the fact is recorded but no change is made in the time. If an incorrect figure is pointed to without change, the record is made of the figure pointed to.

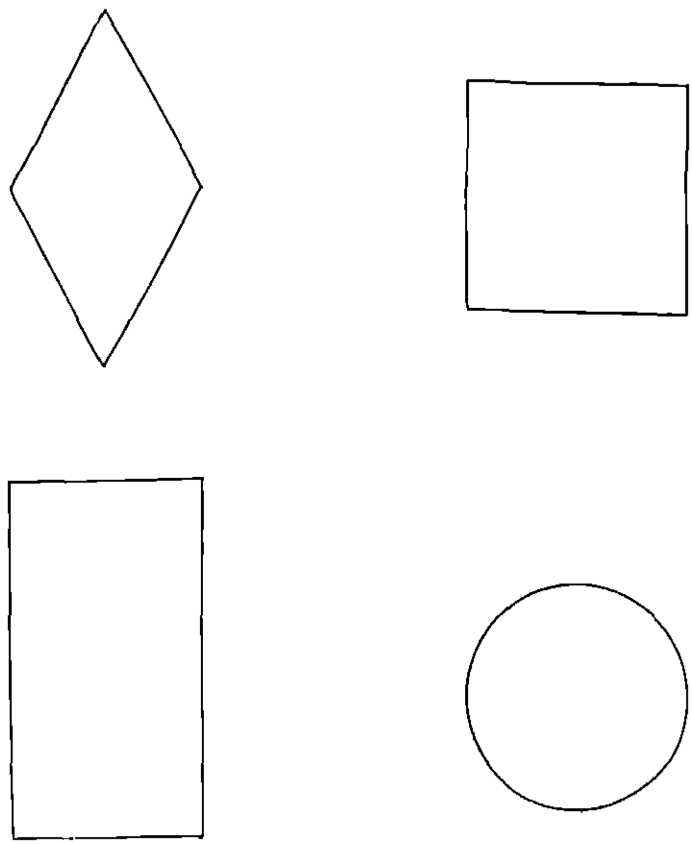


FIG. 2. PERCEPTION OF DIAMOND TEST—CARD 1

Before the second card is shown, the model is turned through an angle of 90 degrees, so that the diamond is shown in the horizontal position instead of the vertical, to coincide with the position of the diamond on the second card. This is done without comment, and in the least noticeable

manner possible. Then the second card is shown, with the directions, "I have another card here with some pictures on it. See how quickly you can find a picture on this card (pointing to the card) which looks just like this (pointing again to the model and taking care that the child's attention is directed to it before the card is shown).)" It is found imperative to exercise great care in giving the directions for the second card so that the

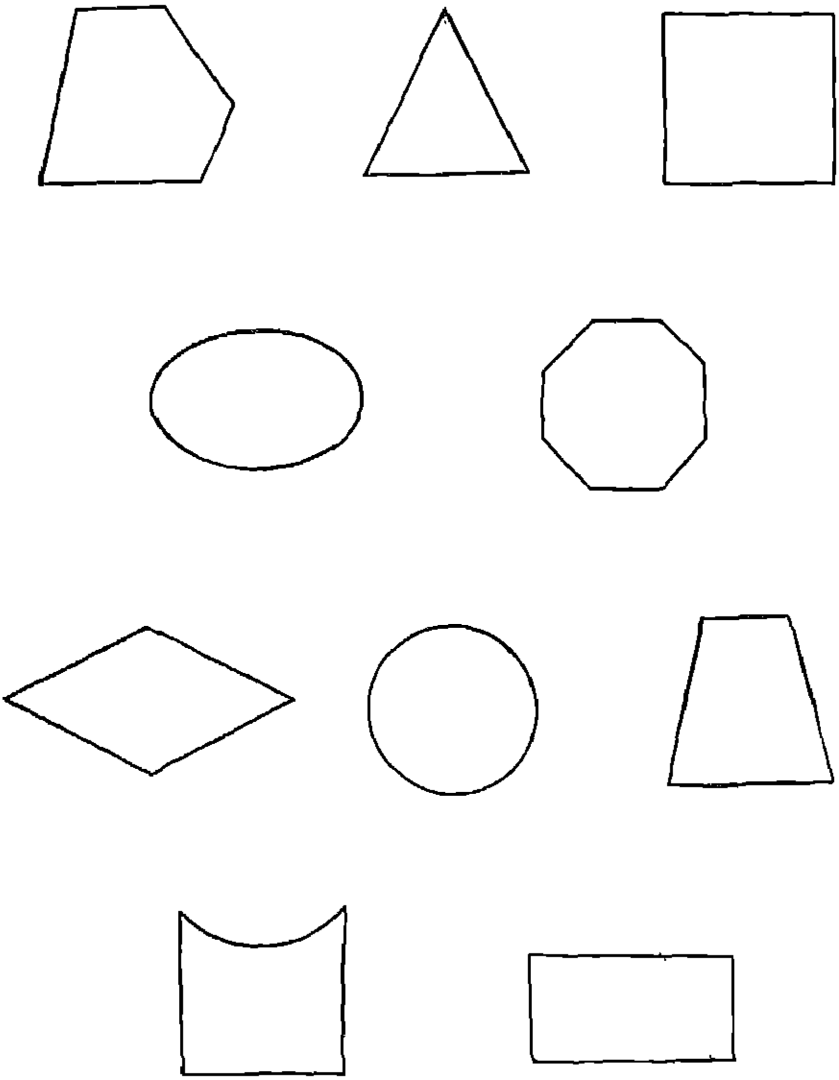


FIG. 3. PERCEPTION OF DIAMOND TEST—CARD 2

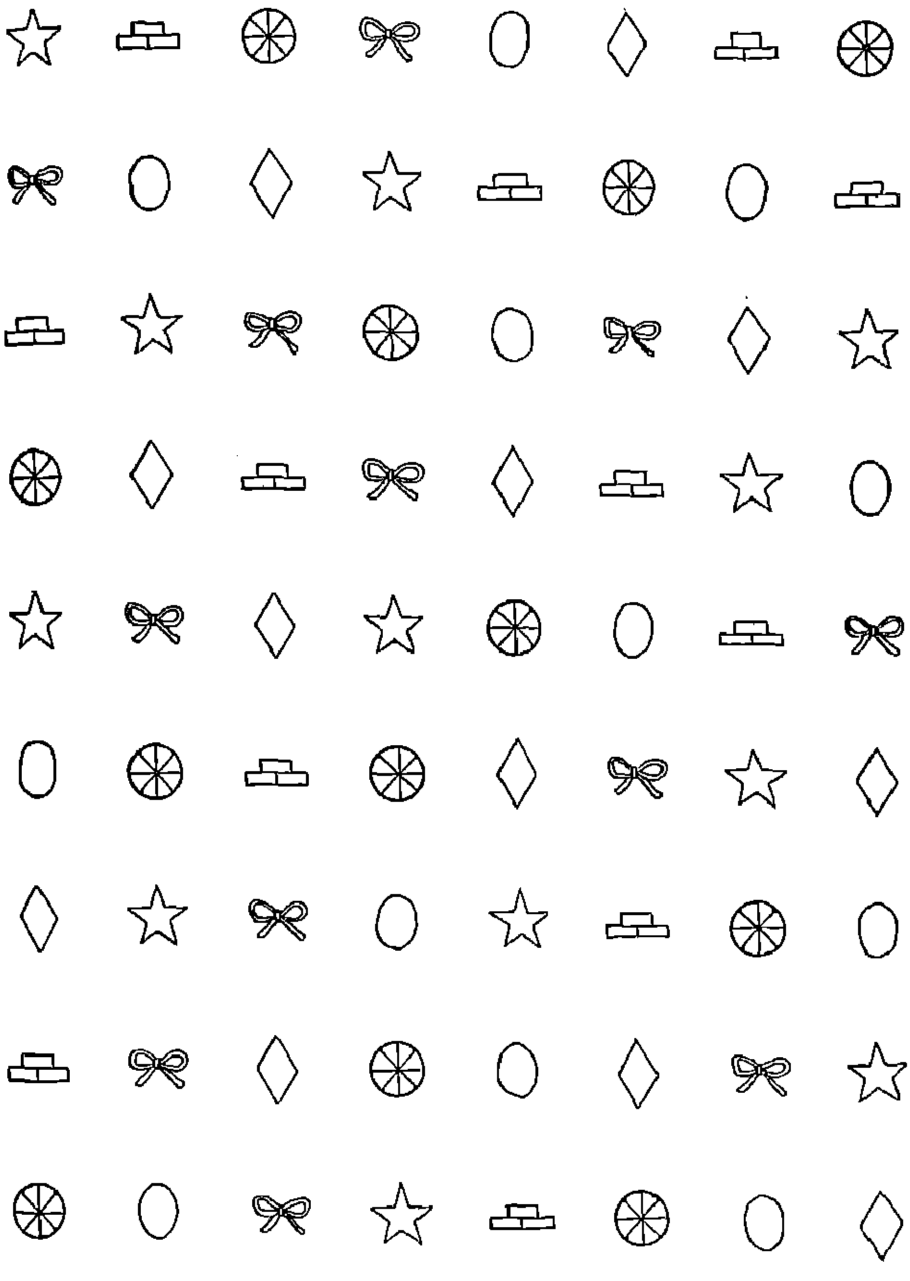


FIG. 4. PERCEPTION OF DIAMOND TEST—CARD 3

FIG. 5. PERCEPTION OF DIAMOND TEST—CARD 4

inflection of the voice on the final "this" should not betray by a rising inflection that the model was in any way different in form or position from the model as used for the first card. As in the first case, no matter what the response of the child, the experimenter accepts it with the assurance "All right."

Before the third card is shown, *no* change is made in the position of the model. In spite of the fact that the diamonds on the third card are in the vertical position, the model is left in the horizontal. The directions here are the same as for the second card, care being again exercised that the child's attention is drawn to the model before the card is shown, and that the experimenter's voice shall give no hint of the fact that there is any discrepancy between the position of the model and the diamonds on the card. If the child states that there is no figure on the card like the model, or if at the end of 45 seconds he has made no response but shows by his actions he is still searching, the model is turned into the vertical position by the experimenter with the question "Now can you find one?" Whatever the response of the child, the experimenter's response remains unchanged, "All right." Finally, with the model still in the horizontal position, the fourth card—which differs from the third only in the fact that half of the diamonds have been turned through an angle of 90 degrees—is shown with the same directions and the same care for details. Again, whatever the response of the child to the card, the experimenter accepts it as in the case of the others. On the fourth card, after the initial choice, the child is asked to point to all the figures he can find which are just like the model. No time is taken for this, and the purpose of the request is to determine whether the child is choosing one position consistently, or is pointing merely to the first one in either position which looks to him like the model.

A record is made of the time and correctness of each response, together with a memorandum of the figures substituted in incorrect responses, and a detailed account of the responses in work or action to the third and fourth cards.

Copying Test: Drawing of Diamond from Memory of Model

The material for this test is the same as that for the first copying test. The child is shown the model in the horizontal position for 10 seconds, and while he is looking, the following directions are given by the experimenter: "I want you to keep looking at this until I take it away. Soon I'm going to take it away and hide it, and then I want you to draw me a picture that looks just like it." If the child's attention tends to wander from the model while the experimenter is talking, the admonition is given to keep looking at the picture all the while. At the end of 10 seconds the model is taken away and turned over on the table, face down, while the experimenter says, "Now, I'm going to take it away and hide it, like this." Then, while placing before the child a slip of paper in the horizontal position, and giving him a pencil, the experimenter says, "Now, see what a nice picture you can draw me that looks just like

the one you have been looking at." If the child insists that he can't, he is urged to "Try anyway." No matter what the result of the attempt, praise is given in the simple form, "That's fine." Occasionally during this test, a child questions the examiner as to which position of the diamond should be drawn. In each case a non-committal answer is given such as "Draw it just as you saw it on the card." The record is taken of the time for drawing. Then the experiment is repeated, with the model and the paper in the vertical position instead of the horizontal.

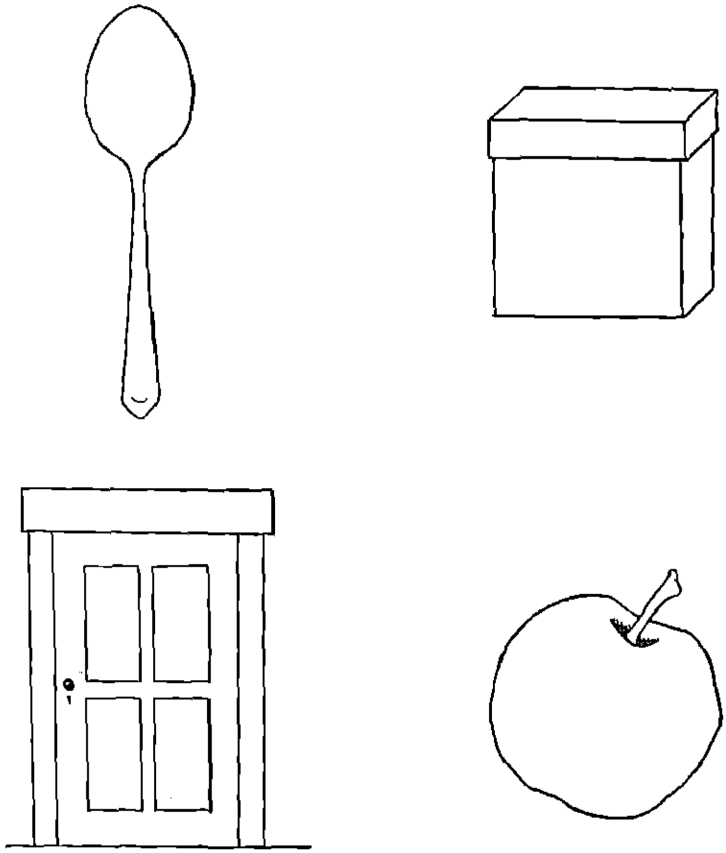


FIG. 6. PERCEPTION OF SPOON TEST—CARD 1

Test of Discriminative Perception: Perception of Spoons—Vertical and Horizontal Position

The second discriminative choice test was devised with the idea in mind that a child's response to the test might be materially altered by the degree of familiarity of the objects figured. The model in this test con-

sists of a spoon drawn to the same scale (approximately) as the model diamond (fig. 1b). The figures on the cards, instead of being geometrical forms are of objects more or less familiar in the life of the child, as may be seen in figures 6 to 9 inclusive. The directions, procedure, and record taken for this test are exactly the same as those for the test of discriminative perception in which the diamond served as the model.

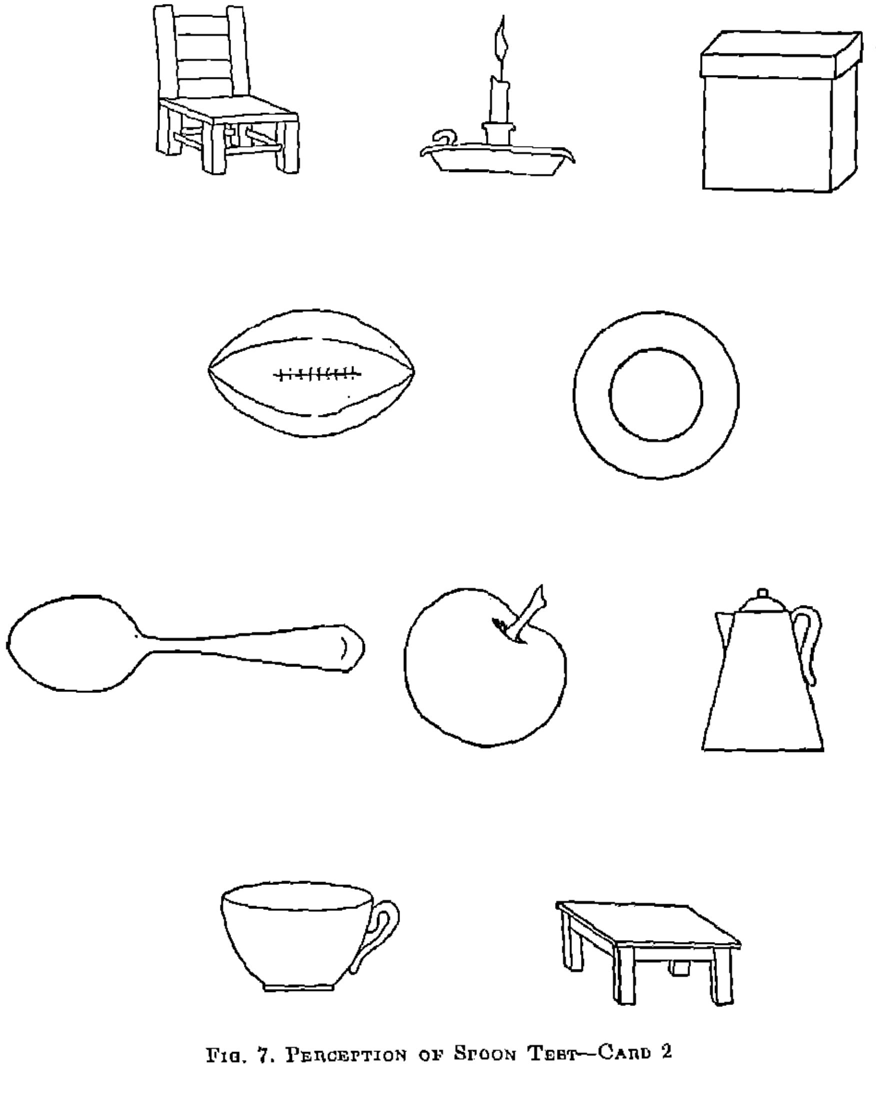


FIG. 7. PERCEPTION OF SPOON TEST—CARD 2

Motor Test: Drawing Straight Line Between Two Dots

The materials for this test consist of a pencil and 4 slips of paper about

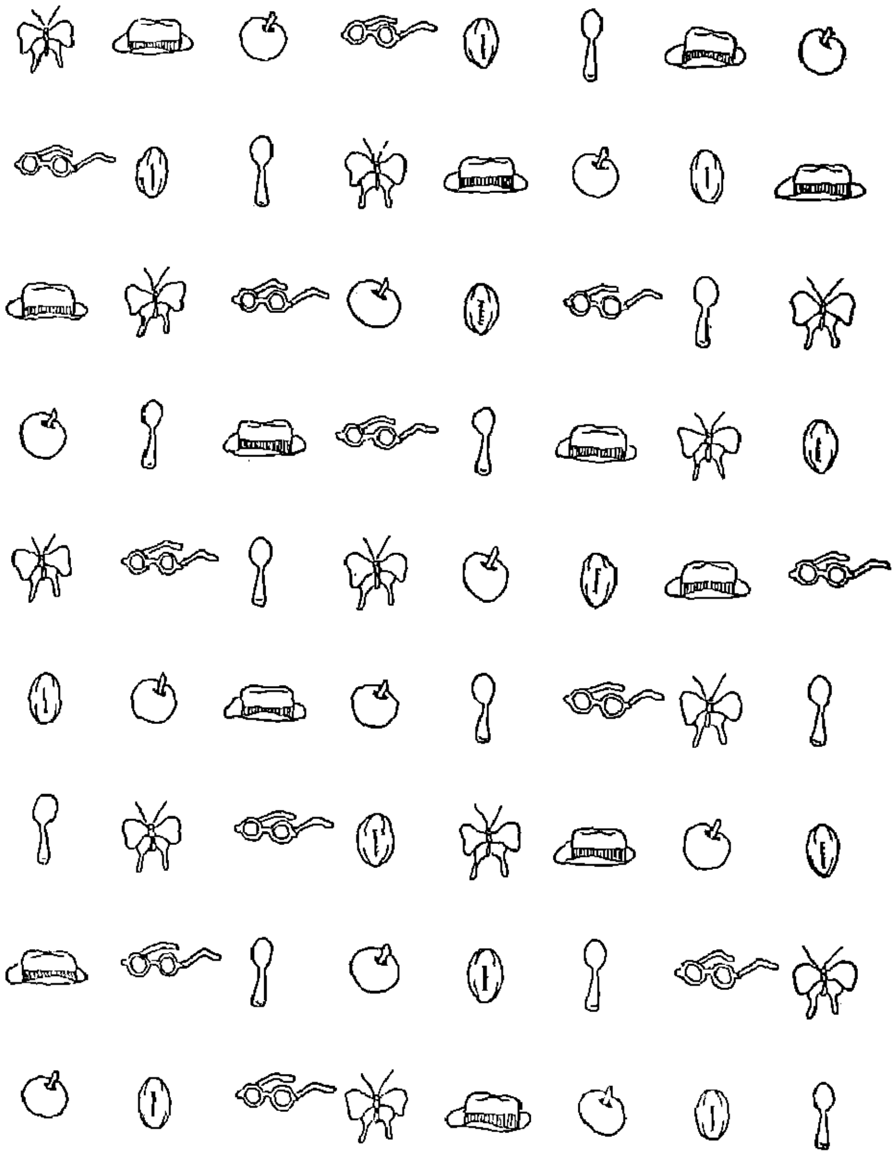


FIG. 8. PERCEPTION OF SPOON TEST—CARD 3

4½ by 5½ inches, on each of which are 2 dots 75 mm. apart. On the first and third slips, the dots lie in a line slanting 30 degrees to the left of the vertical and 60 degrees above the horizontal. On the second and fourth slips, the dots lie in a line slanting 30 degrees to the right of the vertical and 60 degrees above the horizontal.

The child is presented with a pencil

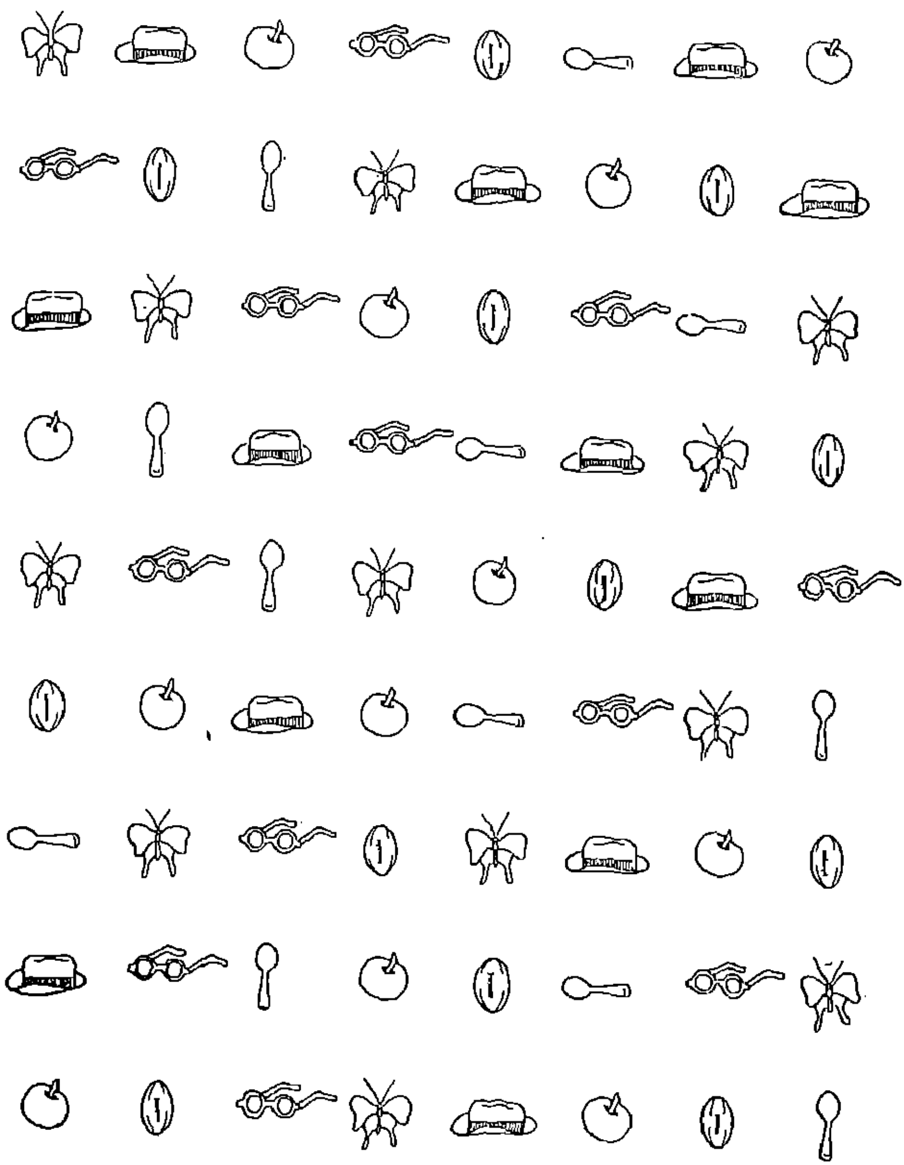


FIG. 9. PERCEPTION OF SPOON TEST—CARD 4

and the first slip with the directions: "See these two dots? I want you to see what a nice straight line you can draw me from this dot here (pointing to the dot nearest the child) to this dot here (pointing to the dot nearest the experimenter). Begin here (pointing again to the dot nearest the child)."

This last instruction checks a frequent tendency to begin drawing at the dot nearest the experimenter.

Time is taken from the moment the child begins to draw until he takes his pencil from the paper. An arrow is used to indicate the direction in which the line is drawn, and the paper is numbered 1, so that any failure to carry out directions may be checked in the analysis.

Three more slips of paper are given, numbered 2, 3, and 4 respectively, for which the directions, procedure, and record are the same except for the fact that the lines are to be drawn in different directions. On the second slip, with its 2 dots in a direction 30 degrees slant to the right of the vertical, and 60 degrees above the horizontal, the line is to be drawn from the one nearest the child to the one nearest the experimenter, as in the first slip. The third slip is like the first in form, and the fourth slip is like the second, but in both cases, the lines are to be drawn from the dot nearest the experimenter to the dot nearest the child.

SUBJECTS

The subjects for the experiment consisted of 226 children between the ages of two years, seven months and nine years, three months secured from the Child Institutes at the Johns Hopkins University and the University of Minnesota, and the kindergartens and first and second grades of two private schools in Baltimore, Maryland. A survey of occupational group and social class was unavailable, but in general the children came from homes of better class business and professional men. Mental ages were available for only 138 of the group, and so could not be used in the evaluation of the data. But the I. Q.'s for those for whom the figures were available ranged from 78 to 158, with 15 cases below 100, and 15 cases above 130, a median of 115.5 and a mode of 116.

The subjects may be first divided into 4 groups according to the type of data which could be collected for them. The standard group (S), of 132 children, is composed of those for whom a complete set of data is available, and for whom the second test period followed exactly two weeks after the first. For the delayed group (D) of 23 children, a complete set of data is available also, but for this group, the second test period was delayed anywhere from 1 to 10 days beyond the two week interval. The incomplete group (I) of 36 children presents data for the first test period only. Finally, a preliminary group (P) of 35 children presents data only for the first discriminatory perception test, and these data are in such form as to be comparable but not identical with the data furnished in this test by the other subjects. Though the procedure was the same, only 3 of the 4 cards were used, and the scoring, done on the basis of 3 responses, and any notes on the behavior of the child, allowed a considerable amount of error to enter into the score given.

In general the unit of age employed was six months. From table 1 it will be seen that the greatest concentration and most even distribution of cases fall in the age groups from four years to eight years, which period, under the conditions of the experiment contains

the critical point in the age scale. Below and above this period other factors enter to a large extent to confuse the data. The justification of the inclusion of these cases in certain uses of the material will be evident later.

TABLE 1

Age distributions according to subject groups

AGES	S	D	S+D	I	S+D+I	P	S+D+I+P
2:1–2:6	0	0	0	0	0	4	4
2:7–3:0	3	0	3	0	3	5	8
3:1–3:6	7	3	10	0	10	6	16
3:7–4:0	3	0	3	0	3	6	9
4:1–4:6	8	2	10	3	13	5	18
4:7–5:0	9	4	13	5	18	8	26
5:1–5:6	11	2	13	4	17	1	18
5:7–6:0	7	1	8	0	17	0	17
6:1–6:6	21	4	25	0	25	0	25
6:7–7:0	18	6	24	3	27	0	27
7:1–7:6	19	0	19	8	27	0	27
7:7–8:0	19	0	19	4	23	0	23
8:1 and above	7	1	8	0	8	0	8
Total...	132	23	155	36	191	35	226

TREATMENT OF DATA

With the material gathered and carefully recorded, the next step consists in devising methods of scoring by which it may be evaluated and compared.

The diamonds are scored according *to their excellency of form.* A score of 1 is given when no attempt to make a copy is evident,—the usual response of children too young to understand the problem. A curved line enclosing a space is given a score of 2 points, and a score of 3 follows a reproduction of certain distinct characteristics of the figure, such as straight line boundaries and angles. An inferior diamond with 4 sides and 4 angles and a semblance of symmetry is given a score of 4, while a score of 5 follows good proportion and correct orientation (fig. 10).

The child's score for the diamond copying experiment is determined from the scores for the 4 separate diamonds as follows: (*a*) If three or four of the 4 scores are the same, the summation score is taken as the same as the identical scores. (*b*) If the scores are divided 2 and 2, the higher number is taken as the summation score. (*c*) If 2 of the scores fall on 1 number, and the other scores are both odd, the summation score is considered as the mean, calculated to the nearest whole number. In every case under this category the estimated score falls on one of the numbers included in the individual scores. These scores, though rough, are comparable to the more or less rough scores of the other tests. Over two-thirds of the scores fall under category *a* above, and another scant fifth fall under *b*, so that in general these scores are quite representative of the ability of the subjects. A further use of the diamond copying scores is made by calculating a summation score for the scores obtained when the copying was done with the model in sight, and one for the scores obtained from memory.

On the perception tests a score of 0 is given for total failure on all 4 cards, a score of 1 if one form is discriminated, of 2 if two are discriminated, and of 3 if three are discriminated. A score of 4 is given for a correct discrimination of form regardless of its orientation on all 4 cards, and a score

of 5 is given for a correct discrimination of form on all 4 cards, with an indication of the difference in orientation on 1 of the last 2 cards. (It is interesting to note that in no case during the entire experiment was there a discrimination *against* the diamonds on card 4 which corresponded in position to the model.) Finally, a score of 6 is given for a correct discrimination of form on all 4 cards, with an indication of the difference in orientation on both of the last 2 cards.

To make these scores comparable for correlation to the 5 scores of the copying and motor tests respectively, the first 4 scores were grouped as 2. 0 and 1 were grouped together as scores in which chance was the determining factor of choice, and 2 and 3 were grouped together as scores in which perception of similarities between forms was just beginning to appear.

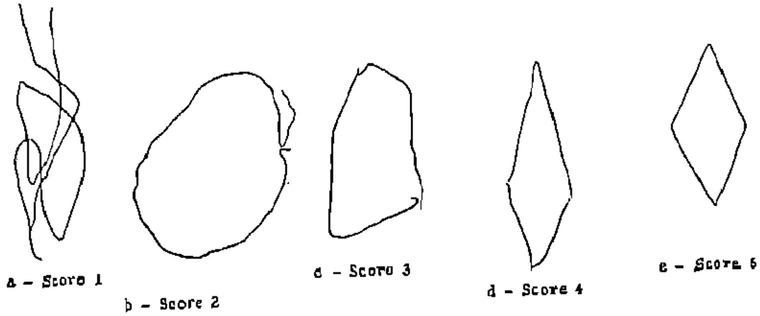


FIG. 10. SAMPLES OF SCORINGS FOR DIAMOND COPYING TEST

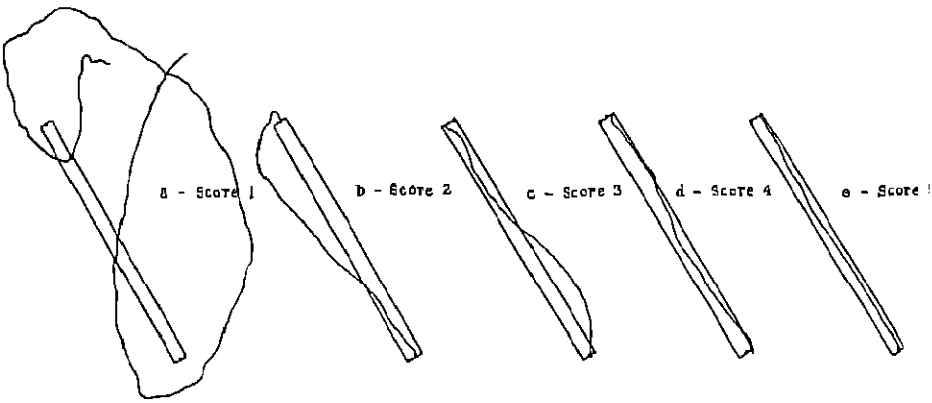


FIG. 11. SAMPLES OF SCORINGS FOR MOTOR TEST BY DETERMINING AMOUNT OF DISTANCE GOVERNED WITHIN 2 MM. RADIUS OF DIRECT PATH

In scoring the performances of the children on the motor test a scale was constructed from transparent celluloid which could be superimposed on the line drawn and so oriented that on it could be roughly measured the amount of deviation of the line from the direct

path between the 2 dots. Both the motor test and the method of marking it are modifications of the test used by Miss Wellman (23) at Iowa, in her study of the development of motor coördination in young children By this scale, it may be determined what percentage of the distance between the

TABLE 2

Frequencies of scores for perception of diamonds

AGES	SCORES 0	1	2	3	4	5	6	TOTAL
2:1–2:6	4							4
2:7–3:0	5		2			1		8
3:1–3:6	4	3		2	5	2		16
3:7–4:0			2		5	2		9
4:1–4:6		2	2	1	12	1		18
4:7–5:0	1		1	2	17	2	3	26
5:1–5:6				1	10	1	6	18
5:7–6:0				1	10	3	3	17
6:1–6:6					9	3	13	25
6:7–7:0					8	4	15	27
7:1–7:6					1	3	23	27
7:7–8:0				1	1	5	16	23
8:1 and above					3	1	4	8
S + D + I + P								226

TABLE 3

Frequencies of scores for perception of spoons

AGES	SCORES 0	1	2	3	4	5	6	TOTAL
2:1–2:6								0
2:7–3:0	1			1	1			3
3:1–3:6	2				8			10
3:7–4:0					3			3
4:1–4:6					10			10
4:7–5:0					10		3	13
5:1–5:6					7		6	13
5:7–6:0					4		4	8
6:1–6:6					5	3	17	25
6:7–7:0					4	2	18	24
7:1–7:6					2	1	16	19
7:7–8:0					1	1	17	19
8:1 and above					1	1	6	8
S + D								155

TABLE 4

Frequencies of scores for drawing of diamonds—Combined scores for drawings from model, and drawings from memory

AGES	SCORES 1	2	3	4	5	TOTAL
2:7–3:0	3					3
3:1–3:6	2	7	1			10
3:7–4:0		2	1			3
4:1–4:6	1	2	7			10
4:7–5:0		3	10			13
5:1–5:6		2	7	4		13
5:7–6:0				8		8
6:1–6:6			10	13	2	25
6:7–7:0			1	21	2	24
7:1–7:6			2	13	4	19
7:7–8:0			2	14	3	19
8:1 and above			2	4	2	8
S + D						155

TABLE 5

Frequencies of scores for motor test

AGES	SCORES 1	2	3	4	5	TOTAL
2:7–3:0	1	2				3
3:1–3:6	2	6	1	1		10
3:7–4:0			2	1		3
4:1–4:6	2		4	4		10
4:7–5:0			7	6		13
5:1–5:6			5	8		13
5:7–6:0			1	7		8
6:1–6:6		1	9	12	3	25
6:7–7:0			10	13	1	24
7:1–7:6			4	14	1	19
7:7–8:0			6	10	3	19
8:1 and above			1	6	1	8
S + D						155

2 dots is covered within 2 mm. deviation from the direct course. A series of 5 scores is used. A score of 1 is given to a performance in which there is no attempt to fulfill the terms of the problem. A score of 2 is given to a performance in which less than 33 per cent of the distance is covered within the 2 mm. radius. A score of 3 is given to a performance in which between 33 and 67 per cent of the distance is covered within the 2 mm. radius, and a score of 4 is given to a performance in which between 67 and 100 per cent of the distance is covered within the 2 mm. radius. Finally, a score of 5 is given to a performance in which 100 per cent of the distance is covered within the 2 mm. radius (fig. 11). In determining a score for a particular child, the per cents for each of the 4 lines are added and the final score is calculated on the basis of one-fourth of the summation values thus obtained.

TABLE 6

Averages and ranges of time in seconds for responses in perception experiments

	DIAMOND TEST			SPOON TEST		
	Number	Average	Range	Number	Average	Range
Total	620	6.1	.2–45.0	020	4.0	.2–45.0
Correct	586	6.1	.2–45.0	607	4.7	.2–45.0
Incorrect	34	6.3	.4–44.0	13	2.2	1.0– 5.6
Card I:						
Total	165	1.8	.2–44.0	155	.9	.2– 7.0
Correct	140	1.4	.2–10.6	151	.9	.2– 7.0
Incorrect	6	10.1	.4–44.0	4	3.1	1.4– 5.6
Card II:						
Total	155	2.5	.4–20.2	155	1.0	.2– 7.2
Correct	143	2.3	.4–20.2	152	1.0	.2– 7.2
Incorrect	12	4.7	1.0–18.4	3	2.5	1.0– 5.0
Card III:						
Total	155	17.3	1.2–45.0	155	14.2	.8–45.0
Correct	147	17.9	1.2–45.0	152	14.2	.8–45.0
Incorrect	8	7.4	1.2–28.2	3	1.5	1.0– 2.0
Cor.—Orient. absent	80	6.2	1.2–40.4	63	4.5	.8–25.4
Cor.—Orient. present	67	31.8	4.4–45.0	80	21.5	1.0–45.0
Card IV:						
Total	155	2.0	.4–24.0	155	2.3	.4–28.0
Correct	147	2.8	.4–24.0	152	2.3	.4–28.0
Incorrect	8	4.7	2.6–14.0	3	1.7	1.0– 2.0
Cor.—Orient. absent	63	3.1	.4–24.0	60	2.4	.6–28.0
Cor.—Orient. present	84	2.6	.4– 8.9	92	2.2	.4–15.4

Such methods of scoring are rough, but the lack of standardization of the tests themselves would obviate finer treatment, and each test, as scored, indicates within itself, a consistent advance in performance ability from year to year (see tables 2, 3, 4, 5).

Experimentation in the handling of the data so as to give an accurate picture of what actually took place, demonstrated that, due to certain gaps in the data at the present time, a treatment of the data as actual frequencies rather than as per cents was much less confusing. For this reason, except in a few special cases which will be clearly stated, the actual frequencies are used as the working figures throughout the treatment of the data.

Time and correctness of response in the perception experiments

A tabulation of the time averages and ranges is given in table 6 for both the perception experiments. From this, the following facts are evident: (1) In all the responses exclusive of those to the third and fourth cards in which orientation is differentiated there is a gradual increase in time required for the response from card to card for the first 3 cards, due to the increased complexity of the task. This is not true for the fourth card which is enough like the third to make the effects of learning evident in the response. (2) The responses for the second experiment are shorter than those for the first, again probably showing the effects of learning. (3) The incorrect responses are longer for the same cards than the correct, with a few exceptions due to the low number of incorrect cases as compared with the correct. (4) Finally, the extreme increase in the reaction times for card 3 is apparently due to the weighting given by the responses in which orientation is differentiated. Such responses are lengthened by the fineness of the differentiation required, and are frequently accompanied by hesitations and comments which show a recognition of the reversed position of the figure, and which indicate that the response is to 2 similar figures in different positions, rather than to 2 different figures. After the third reaction, the reaction to the fourth card becomes a relatively simple matter, as is indicated by the very much lower time average for this card than for the third. The third card, then requires the solution of a problem by the child, and the way the problem is solved seems to throw a good deal of light on the stage of development the perceptual life of the child has reached at the time of the experiment.

The factor of orientation as treated by the first perception experiment

The point of primary interest in the experiment is the analysis of the distribution of scores in the discriminatory perception tests, and of the bearing of the results on the question of orientation of figures as a factor in their perception. For this analysis, the material in the S, D, I, and P groups is used, for though the data in the last group have been collected under slightly different conditions, the age range of the group is such that, if its inclusion is justifiable at all, it will serve to add materially to the clearness of the frequency curves. It is felt that its inclusion is justifiable, moreover, because of the very slight change which occurs in the form of the frequency curves when these data are added. A study of the probabilities of curve fit showed that only in 1 age group does the figure drop below

.8, and in this particular case, the accumulated frequency of the S, D, and I groups is increased 200 per cent by the addition of the P data. Considering the small number of cases included, the probabilities are great enough to justify the addition of the data in the P group to those of the other three groups.

The curves of this distribution of score frequencies plotted from the data of table 2 are shown in figures 12 and 13. In figure 12, which shows the curves for scores 0 to 3 inclusive, in spite of the still too scanty number of cases, the general tendency for each succeeding score to persist to a greater age than the one just below it is evident, showing a gradual development of perception from a stage of no recognition to one of fairly accurate discrimination. A closer inspection of the various kinds of responses for which these scores stand is interesting in this connection. The 0 scores, obviously, are those in which all 4 responses (3 in the case of the P data) are to figures other than the diamond. With one exception these occur below the age level of 3 years 4 months. The score of 1 has 4 possible forms. Of these, 3 occur, and within the 5 cases, 3 of the correct responses fall on the first card, and 1 each on the second and third. It is somewhat doubtful whether such responses indicate anything more than chance successes. The predominance of successes on the first card may indicate that the perceptual ability is there but that the child has not yet developed a sufficient degree of concentration to carry the problem in mind without distraction through the 4 responses. At least it rather obviates the possibility that the main cause for error is a lack of understanding by the subject of the problem in hand. The elements of chance success and lack of concentration seem to carry over into the 2 score. Here, in the total of 7 cases, 3 made correct responses to the first and third cards, 2 to the first and second cards and 1 each to the second and third and to the third and

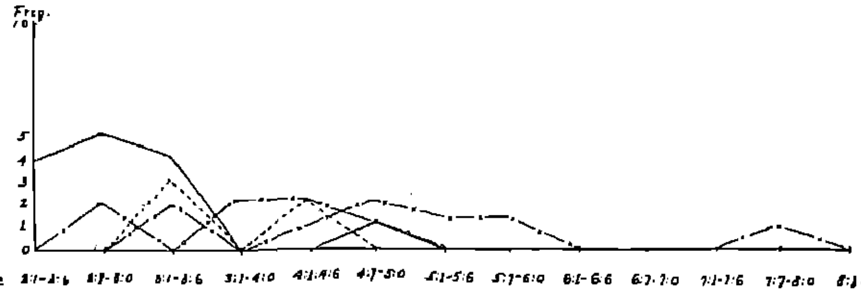


FIG. 12. SCORE FREQUENCIES FOR AGES—FIRST PERCEPTION TEST—SCORES 0, 1, 2, 3—S + D + I + P

——— = 0 score.
---------- = 1 score.
—o—o— = 2 score.
—x—x— = 3 score.

fourth cards. For the score of 3 less variation is shown than would seem probable. Six of the 8 cases indicate correct responses for the first, third and fourth cards, and the other two for the second, third and fourth cards. The predominance of errors on the second card, and the form those errors take indicates that the low score is a lack of appreciation of the problem to which the response is to be made.

A further analysis of the types of errors made in scores 0, 1, and 2 indicates an interesting course of development in discrimination. Of the 46 possible responses included in the 0 scores, 1 response was wholly negative, 10 consisted in pointing to each figure

FIG. 13. SCORE FREQUENCIES FOR AGES—FIRST PERCEPTION TEST—SCORES 4, 5, 0—
S + D + I + P

——— = 4 score.
--------- = 5 score.
—o—o— = 0 score.

caused mainly by the fact that the child has not yet reached the age of critical discrimination of form. Four of the 6 errors on the second card consist *in responses to triangles*, and the other 2 in responses to a truncated triangle and a rectangle respectively—all forms very similar to the diamond. The 2 errors on the first card consist in responses to the circles, and may indicate on the card in turn, 27 consisted in pointing to a circular figure (the circle on the first 2 cards and either the elipse or the wheel on the last), 3 to a rectangle, and one each to a curved-topped quadrilateral, a star, a hexagon, a pyramid of three bricks, and an irregular quadrilateral. The great predominance of responses to the circular figures is interesting in connection with

the general contention that circles are the first recognizable drawings made by children, and probably the first plane figures recognized by them. The response of pointing to each figure on the card in turn is also indicative of a very early stage of the response and does not occur except in the 0 score group. Among the cases scoring 1 point the responses to circular figures still appear as the most frequent errors, and comprise 4 of the 13 possible responses. After this, stars and rectangles occur twice each, and there are single responses each to the triangle, curved-topped quadrilateral, irregular quadrilateral, pyramid of bricks and bow. Here we find an increase in the proportion of angular figures. Whether or not we can say that the child is choosing them because they are more like the diamond is doubtful. But at least we are approaching a broader field of recognition than that limited to the circular forms. This field broadens still farther in the cases in which 2 correct responses are given. Here, of the 0 instances of error only 3 are circular figures, while 2 are triangles, and single cases occur of the rectangle, curved-topped quadrilateral, pyramid of bricks, and bow. Though there is here a lack of any particular emphasis on the circular figures, the figures chosen, as a whole, do not yet bear any striking resemblance to the diamond, as is true in the errors recorded in connection with the scores of 3.

With this picture of the general perceptual development as a background, it is most interesting next to compare the curves for the next 4 scores, all of which stand for perfect discrimination of the diamond, but with different qualitative factors included. In figure 13, which shows the curves for scores 4 to 6 inclusive, an exceedingly interesting period of development is displayed. Appearing as early as three years in a few scattering cases and rising rapidly to a climax between four and one-half and five years, the recognition of likeness between the 2 figures, regardless of their orientation on the sheet—as represented by a score of 4—begins to drop off in the face of the rising scores 5 and 6. Indeed, scores 4 and 6 show a very beautiful opposition representative of the antagonism of the 2 responses implied. For the recognition of likeness between 2 figures only when they are identically oriented—as represented by the score of 6—not only develops after the state represented by 4, but develops to its final exclusion. Score 5, on the other hand, representing an apparent state of doubt on the part of the child between scores 4 and 6, shows no peak between the peaks of these scores—a situation which might have been expected rather than the one shown. In fact, the distribution of score 5 as it appears in the curves raises a strong question whether the jump from a score of 4 to a score of 6 is not a sudden one, with no intermediate step, and whether the score here represented by 5 may not represent an even greater mental development than that represented by 6. On the face of it the drop of the curve of score 6 from a frequency of 23 at seven to seven and one-half years to a frequency of 16 at seven and one-half to eight years, and a coincident rise of score 5 from 3 to 5 during the same

time may be significant. Beyond eight years, the forms of the curves are not significant—a fact which was previously stated in the discussion of the choice of subjects. Whether the *addition* of more subjects in age ranges above these studied here would lead to a further drop in the curve of score 6 and a corresponding rise in the curve of score 5 will need further experimentation to determine. If, as Dunlap has stated, in developing perception we are at the same time developing thinking by laying in store elements later to be used in thinking, might not the state represented by score 5 be one in which a more comprehensive integration of perceptual elements had been utilized, i.e., a state in which simplicity of response had given place to a complexity of possible responses which made the final choice doubtful, hesitating, and perhaps we might say, more thoughtful than the rest. A closer analysis of the actual responses grouped under the score of 5 may throw some light on the matter.

The absence of card 4 from the P group obviates the use of these data in such an analysis, but among the total number of 191 cases included in groups S, D, and I, 24 received a score of 5 on the first perception experiment. Three of these 24 cases were instances in which the child responded to the third card negatively, in one case being unable to find a figure like the model until the model had been turned into the position of the diamonds on the card, and in the other 2, pointing to some of the diamonds on the card, but objecting to the fact that they were turned in the wrong direction. At the presentation of the fourth card, however, both positions of the diamond were pointed to without discrimination in all three cases. In the 2 cases which commented on the difference in orientation, each child seemed perfectly *conscious of the factor*, but seemed to be having difficulty in deciding whether the experimenter wanted the diamonds pointed out with reference to or in spite of it, and finally decided to do it in spite of the factor. The other case showed nothing by which such an interpretation could be made.

In the other 21 cases, the situation was reversed. Here the diamond on card 3 was pointed to with little or no hesitation and without any apparent consideration of orientation as a limiting factor. But upon the presentation of the fourth card on which diamonds appeared in both positions only those in the same position as the model were indicated. In no case was there any attempt on the part of the child at an explanation of what to an adult mind would be an ambiguous response. The child was apparently solving each situation as it came up. Either the lack of any diamonds on the first card to correspond exactly with the model led to the choice of the second best, and the presence of both kinds on the fourth card led to the choice of only those most exactly like the model, or else the presence of the 2 kinds on the fourth card called the child's attention to a factor which he had not noticed before, and served as a suggestion to him to treat the situation in a new way. *If the latter is the case it* may well be argued that the reaction receiving a score of 5 is a more intermediate response between the reac-

tions represented by scores 4 and 6. If the former is the case the reaction would seem to be more that of indecision on the part of the child as to just what sort of a reaction is wanted. There is nothing within the experiment itself by which the possible attitude of the child can be discovered, or by which we are justified in assuming one explanation or the other for the occurrence of a reaction corresponding to score 5.

A tabulated comparison of the responses to cards 3 and 4 for all the 191 cases in groups S, D, and I show that 88 per cent of the responses are in agreement on the 2 cards, while only 2 per cent (those receiving score 5) are in disagreement. Of the 88 per cent in agreement, 5 per cent (including all individuals having scores of 0, 1, and 2) were consistently incorrect, 41 per cent (including all individuals having scores of 3 and 4) were consistently correct, but showed no sign of the recognition of differences in orientation, and 43 per cent (including all individuals having a score of 6) were consistently correct and cognizant of orientation as a factor in the perception of likeness in plane figures. The relatively small number of inconsistent responses would lead one to one of two conclusions, either that the stage of uncertainty, if existing, as was first thought, between types of responses represented by scores 4 and 6, is extremely transient, and is caught only very infrequently by such a test, or the inconsistent response is a more mature response than those represented by either score 4 or score 6, and so is only beginning to appear in the age range here covered. Careful developmental study of a considerable number of individual children over a number of years would indicate any bases for accepting or discarding the first conclusion, while an extension of the upper age limit on the present experiment would go far in justifying or eliminating the second. The status of the scoring in this experiment is as yet so much that of uncertainty that it is impossible to state arbitrarily, without this further study, that one of these three higher scores indicates a more mature response than another. We can merely point to the results of the experiment as indicative of a fairly clear state of affairs during the ages two and one-half to eight years, and leave the significance of the various responses, in the light of maturity of development to be determined after further experimentation at other age levels.

A comparison of the first and second perception experiments with a view to the part familiarity of the figure may play in the modification of the reaction to orientation

A comparison of the first and second perception experiments involves only the data from subject groups S and D. The justification of the use of the D data in the second perception test (which might be questioned because of the variability of the time between the 2 test periods for this group) is based on a comparison of the closeness of fit between the frequency curves for the 2 groups on the first test, and the closeness of fit between the curves for the 2 groups on the second test. In only one case does the difference between the closeness

of fit in the first experiment and the closeness of fit in the second exceed twice the value of sigma and become significant, and that particular instance is one in which the discrepancy lies obviously in the low value of the probability in the first perception experiment.

In proceeding, then, to a comparison of the results obtained on the first perception test with those obtained on the second test, for the S and D groups —155 cases in all, it was assumed at the outset that the factor of familiarity of the figures might in some way affect the influence of the factor of orientation, and that if this influence were present, it would probably be on the side of lessening or even eliminating the effect of orientation, so that the child would pay no attention to the position of the figure in his choice. Here ease of recognition would increase the likelihood that slight differences of detail would be overlooked. A general correlation between the scores on the two tests irrespective of age gives $.66 \pm .032$. This correlation, in the absence of other tests of the same factor to which this test may be compared, shows a good reliability of the test within itself. It also seems to indicate that though there may be some factor entering in the second test which was not present in the first, to keep the correlation from being higher, whatever that factor is, it does not have any tremendous effect one way or the other. A close analysis of the changes in score from one test to the other will be interesting in this connection. If the factor is the one of familiarity mentioned above, one would expect to find a good majority of losses in score over gains, especially among the scores 4, 5, and 6. As a matter of fact, in the 45 cases in which a change in score occurs between the first experiment and the second, there are 36 cases in which the score is raised and only 9 cases in which the score is lowered. Each of these 9 cases, moreover, represents only a single point's loss, one being a drop from a score of 1 to a score of 0, 7 being drops from scores of 5 to scores of 4, and 1 being a drop from a score of 6 to a score of 5. The gains, on the other hand, not only predominate four to one in number, but range in magnitude from one to four points and total 62 of the 71 total points of change recorded between the 2 experiments. A detailed table of the gains and losses will be found in table 7. It is fairly certain from this that familiarity with the figure, if it does serve as a limiting factor, does not tend to overshadow the factor of orientation. If anything, it tends to sharpen it, though

TABLE 7

Detailed table of gains and losses in score for whole group,—from diamond perception test to spoon perception test

LOSSES				GAINS			
Score		Frequency	Per cent of total	Score		Frequency	Per cent of total
From	To			From	To		
1	0	1	11	0	3	1	03
5	4	7	78	0	4	2	05½
6	5	1	11	1	4	2	05½
				2	4	1	03
				3	4	5	14
				3	6	1	03
				4	5	3	08
				4	6	11	30
				5	6	10	28

the tendency to increase in score is probably not sufficient to warrant the assumption of any factor other than the mere greater familiarity with the procedure which the child experiences at the second test period.

The probability that greater familiarity with the procedure of the second test is the determining factor in changes in score between the two tests is heightened by an inspection of table 9. From this it is evident that 28 of the 45 changes—both gains and losses—are from one of the doubtful scores, 0, 1, 2, 3, or 5 to one of the positive scores, 4 and 6, and 11 of the gains are from score 4 to score 6, i.e., from one positive score to another more advanced. Thirty-nine, then, of the 45 changes are toward greater certainty. Two, one loss in score from 1 to 0, and one gain in score from 0 to 3, are from hesitation to hesitation in nature, and only 4, one loss in score from 6 to 5, and three gains in score from 4 to 5 show a change from positiveness to hesitation. In general, then, on the second test the children were much surer of what they were going to do, and probably the correlation between the 2 tests is as low as it is, merely because of the greater familiarity of the children with the experimental procedure at the second test period, and not because of the interference of a factor of familiarity of the figure with the factor of orientation. This point could be assured by reversal of the order in which the 2 perception tests are presented to the children.

A further analysis of the distribution of the changes in score shows that they are fairly evenly distributed over the age range. Twenty cases of change occur in the first 3 years of the age scale, from two years seven months to five years six months, and 25 cases occur in the last $3\frac{1}{2}$ years, from five years seven months to nine years three months. Of the 20 cases of change in the first half, 15 are cases of gain and 5 are cases of loss, while of the 25 cases of change in the second half, 21 are cases of gain and 4 are cases of loss. Among the gains, those of the greatest magnitude are confined to the earlier 3 years. In this group are 100 per cent of the gains of 4 points and 3 points, 25 per cent of the gains of 2 points and 33 per cent of the gains of 1 point, and the other 75 per cent of the gains of 2 points and 67 per cent of the gains of 1 point comprise the total number of gains in the last three and one-half years.

Generally speaking, though the gains and losses are fairly well distributed over the age scale, the gains for the first three years average much larger than those for the last three and one-half years. This fact in itself would tend to lower the correlation between the 2 tests, and further emphasizes the fact that it is probably the greater familiarity with the procedure of the second test which accounts for any differences between the 2 performances.

Comparison of the tests of discriminative perception with the related tests of copying and motor control

It remains now to show what bearing performance on these tests of discriminative perception has on the ability of a child to copy a given figure, and to compare the relative

parts perception and motor ability play in such copying. For this only S and D data are used.

Because of incomparable scaling of the perception tests as compared with the better standardized scores on the other two tests correlations are of little significance except to indicate the possible validity of the scoring of the perception tests themselves. A better comparative picture of the responses given on the respective tests is gained from tables 8, 9, 10, 11 and 12.

While the table giving the scores of the diamond copying test as compared with the motor test scores shows an even progression between the 2 tests, the tables giving the score

TABLE 8

Frequencies of scores for perception of diamonds as compared with scores for copying diamonds

PERCEPTION OF DIAMOND—SCORES	DIAMOND COPYING TEST—SCORES				
	1	2	3	4	5
6			13	45	8
5		1	5	9	5
4	1	9	21	22	1
3		3	3		
2		1	1		
1	2	1			
0	3	1			

TABLE 9

Frequencies of scores for perception of spoons as compared with scores for copying diamonds

PERCEPTION OF SPOON—SCORES	DIAMOND COPYING TEST—SCORES				
	1	2	3	4	5
6			18	56	12
5			1	6	
4	4	12	26	15	1
3	1				
2					
1					
0	1	2			

TABLE 10

Frequencies of scores for perception of diamonds as compared with scores for motor test

PERCEPTION OF DIAMOND—SCORES	MOTOR TEST—SCORES				
	1	2	3	4	5
6			19	42	5
5	1		7	11	1
4		3	23	26	2
3		1	1	4	
2	1	1			
1	2	1			
0	1	3			

TABLE 11

Frequencies of scores for perception of spoons as compared with scores for motor test

PERCEPTION OF SPOON—SCORES	MOTOR TEST—SCORES				
	1	2	3	4	5
6			28	53	0
5			3	3	1
4	4	6	10	27	1
3		1			
2					
1					
0	1	2			

TABLE 12

Frequencies of scores for diamond copying test as compared with scores for motor test

MOTOR TEST—SCORES	DIAMOND COPYING TEST—SCORES				
	1	2	3	4	5
5			2	5	1
4		5	20	47	11
3		5	19	25	1
2	4	4	1		
1	2	2	1		

frequencies for the perception tests and the others show the difficulty which arises in trying to get an even progression between two tests graded in such a manner that one presents a unimodal curve of frequency and the other a bimodal, and that while one is scaled high enough so that there is a drop in frequency at the end of the curve, the other is not. In spite of this, however, there is indicated a more or less parallel progression of the two sets of scores in each case. This is more true of the tables comparing the scores of the first perception experiment with the other tests than of those comparing the second perception experiment with the same tests—a fact which bears out still further the contention of a difference between the factors involved in the two perception tests.

The correlations serve to show some interesting tendencies (see table 13). The first thing of note in these figures is the lowness of the correlations between the second perception experiment and the diamond tests in comparison with the substantial correlations between the first perception experiment and the diamond tests. This phenomenon is explainable first on the grounds that the first perception experiment and the diamond tests were done on the same day, while the second perception test was performed two weeks later, and second, by the factors of learning and greater familiarity with the procedure epxerienced in the second test period. The scores on the first perception test are undoubtedly a more accurate estimate of the general state of the child's perceptive ability along the lines indicated than scores on the second perception test, and for this reason the fairly high correlations between this test and the diamond test are of vast interest in indicating a parallel development of perception and ability to copy figures.

TABLE 13

PERCEPTION OF	DRAWINGS OF	r	PEr	Pr
Diamonds	: All diamonds	.35	.032	.0000006
Spoons	: All diamonds	.01	.05	.865
Diamonds	: Diamond from model	.37	.047	.00000022
Spoons	: Diamond from model	.16	.05	.0424
Diamonds	: Diamond from memory	.46	.05	Negligible
Spoons	: Diamond from memory	.25	.05	.000038

TABLE 14

FACTORS INVOLVED		r	PEr	Pr
All diamonds	: Motor Test	.18	.05	.0208
Memory diamond	: Motor Test	.25	.05	.000038
Visible diamond	: Motor Test	.25	.05	.000938

The second point of interest in the above figures lies in the fact that the highest correlation is between the perception of diamonds and the dia-

mond drawn from memory. The factor of holding a memory image of the figure long enough either to find it again or to reproduce it seems to bind these 2 tests together. The correlation between the memory diamond scores and the visible diamond scores is .36 ±.047, and the fact that the correlations between the first perception test and the diamond copying test are as high as or higher than this correlation is an added point in favor of conceding some slight significance to the figures.

The correlations between the scores for the diamond copying tests and the scores for the motor tests are shown in table 14. They are positive, but less significant, a fact doubly interesting because these correlations are between 2 relatively well standardized tests.

Finally, the correlation between the scores on the motor test and the scores on the first perception test is found to be .68 ±.03. This is the highest correlation to be found in the whole group, and is interesting in view of the axiom derived from the response hypothesis that accuracy of motor response is a basis for accuracy of perception and later of thought. It may be that precocity in general motor development is paralleled by a corresponding precocity in the development of perception, and that the reason the correlation between the motor test and the diamond drawing tests is not greater lies in the greater complexity of the factors involved in the diamond drawing tests which are as yet unanalyzed and confuse the issue.

The probability of entrance of extraneous factors into the second perception test is strikingly substantiated, in the view of the last paragraph by the fact that the correlation between this test and the motor test is −.17 ± .05.

To return to the nature of the response scored as 5 on the perception experiments in the light of this discussion—if score 5 is in reality a superior score to score 6, we would expect to find that the motor scores for children receiving scores of 5 on the first perception experiment would be relatively higher than those for the other children. But, in 10 of the 20 cases in which these data are available, the scores on the motor test fall exactly on the modes of the score frequency curves for the particular ages, in 7 cases they fall 1 point below the mode, and in 3 cases they fall 1 point above. Very little conclusive evidence is to be obtained from this survey, and what may be obtained rather disavows any superiority in the children scoring 5 on the first perception test.

CONCLUSIONS

Summarizing, it must be said that the results are on the whole indicative rather than conclusive. The subjects are too few, and there is too little material with which to compare the results of the tests, to give the interpretations herein presented other than a tentative aspect. A few points, however, are clearly brought out as follows:

1. Orientation on the page, of plane figures, appears to rise rather suddenly as a factor in their perception between the ages of 5 and 6 years—or between the standard kindergarten age and the

standard first grade age. The break is apparently rather sudden for the individual child with little or no transition; and for the group, it may be located much more exactly than one might expect.

2. In the work here outlined, the degree of familiarity with the figures used in the perception tests seems to bear little or no relation to the reaction toward the orientation of the figures on the part of the child. Any relation which may exist, is in this case obscured by the effect of greater familiarity with the test procedure at the second test period.

3. The first perception test may be taken as a truer measure of the child's general perceptual development along the lines indicated than the second perception test, because of its greater freedom from any factor approaching that of learning.

4. Perceptual development appears to be more closely allied than motor development with development in imitative drawing.

5. A very high correlation exists between scores on perception and scores on motor control. Just what this means is speculative, but it is highly probable that it is indicative of a very close interplay of the two factors in the course of the development of the child.

6. Aside from these general points, a specific field for further speculation and investigation lies in determining the significance of ambiguous performances and in determining the relation of the responses given at these ages with those of adults.

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An Adaptation of the Ishihara Color Test for Use with Children of Pre-School Age

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IN THE absence of objective data, the usual viewpoint as to color vision and color discrimination in the pre-school child has been similar to that expressed by Spindler (3):

> "It seems certain that the perfectly normal child for some time after birth is color blind. The probability is that there is no accurate discrimination of colors felt by the child till he is three or four years old, and that the discrimination is exceedingly imperfect and proceeds very slowly and requires much time and training."

Sulina (4) reported an attempt to study in a fairly comprehensive way the development of color sense in children. He tested 336 children from one to fourteen years of age and concluded that the color sense is not developed under two years (15 cases), but that it begins to function and can be demonstrated at two years (29 cases), becoming completely developed between the fourth and sixth year (53 cases).

This article reports an attempt to adapt the Ishihara tests for color blindness for use with children approximately four to six years of age. If color sense is developing gradually toward perfection during this period, it would be interesting to have an easily applicable test which would show how far any individual child's color discrimination had proceeded.

For use with children of three to six years of age a matching test on a multiple choice basis was devised, the idea being that children of this age could show by matching the correct number with each of the Ishihara plates whether or not they could see the numbers on them as an adult of normal color vision would.

The Ishihara tests (2) consist of 16 plates, of which numbers I through XIII only were considered suitable for this adaptation. Each of the Ishihara plates shows a number made up of small dots of color on a continuous background of other similar dots of different hues. Each plate is so constructed that people of normal color vision can easily read the number correctly, while the color blind will read it as a different number (e.g. 3 instead of 8 for Plate II) or will be unable to read it at all. Two of the plates (X and XI) are so devised that the majority of the red-green blind will read a figure in each, while the majority of the normal (and the totally color blind) cannot see any number there, or can hardly read it. Thus the difference between the normal and the ab-

normal individuals in color vision is shown by the way they read the Ishihara plates.

A preliminary test of each child was necessary to show whether he could match numbers when the element of color was not involved. For this purpose a series of numbers was painted (black on a white background) on tracings of each of the numbers on the Ishihara plates, so that the black numbers would be of the same size,

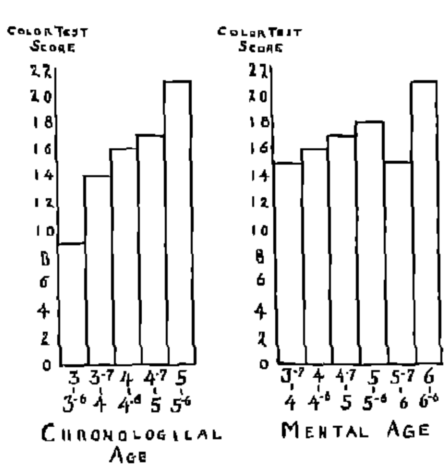

FIG. 1. MEDIAN SCORES FOR EACH AGE LEVEL

and similarly constructed of a series of dots rather than a continuous line. In the preliminary test each child was shown 4 at a time of these black numbers. The number to be matched was then placed just below the 4 and the instruction given to "find another one up there (pointing to the row of 4) just *like* this one: another one that is just the *same* as this one." The time required to match the number was taken by a stop-watch. In this preliminary test, if the child indicated a wrong number, the two were placed side by side and the question asked, "Are they the same"?, while the number was traced with the forefinger. In practically every case, the child then quickly made the correct choice, and very rarely was there more than one mistake of this kind in matching the series of black numbers.

For the color test proper, a series of numbers was made with water colors, duplicating as nearly as possible all the numbers on the Ishihara plates as they would be read by those of normal and of defective color vision. From these a multiple choice series of 4 numbers was selected for presentation with each plate, the series consisting of the correct number to be chosen by the normal, the number which a color blind person would be expected to see and two other numbers different in form and color from the two just mentioned. The position in the series of the correct and color blind choices was changed for each plate, so that choice would not be made on basis of position in the row. In giving the test, the Ishihara plate was placed below the row of 4 numbers and the child told, as in the preliminary test, "Find another one up there *just like* or just the same as this one." The time of each choice was also recorded, and any relevant remarks by the child or anything unusual in his manner of attacking the task were also noted. The series as presented for multiple choice with each Ishihara plate is given in table 1 with the normal and color defective scoring as given in the Ishihara booklet.

The Ishihara instructions say that "it is essential that the test should be conducted in a light room in the day-

time.' In this experiment with children, the tests were given only on sunny days and the child was seated near a window, though the sunlight did not fall directly on the cards. Even on sunny days, however, the illumination is far from constant, as it varies with the time of the year and with the frequency of clouds which may now and then pass across the sun. In the interests of eliminating variability in illumination, it would un-undoubtedly have been preferable to give all the tests under standard artificial illumination, such as the Nela Daylight Screen.

TABLE I

ISHIHARA PLATE NUMBER	MULTIPLE CHOICE NUMBERS	SCORING	
		Normal	Color Blind
I	5–12–7–6	12	12
II	3–5–8–2	8	3
III	2–5–7–6	6	5
IV	5–6–8–2	5	2
V	21–5–74–42	74	21
VI	6–5–2–8	2	†
VII	2–8–5–6	6	†
VIII	5–8–20–2	5	†
IX	6–7–2–8	7	†
X	8–6–5–74	*	5
XI	6–74–8–2	*	2
XII	6–74–26–2	26	Red blind 6 Green blind 2
XIII	4–74–2–42	42	Red blind 2 Green blind 4

* Majority can hardly read it.
† Can hardly read it.

One other minor point in technique is that of presenting the cards rapidly enough to sustain the interest and attention of children of this age level. Giving the whole test takes from twelve to fifteen minutes, not a long time, but there is little variety and not much inherent interest in the material for the pre-school child.

Mechanically the presentation is facilitated by having the multiple choice cards in a box similar to a small file with identifying tabs on each card, so that the four for each series can be quickly selected. It is also necessary to return each card to its place in the file after each choice, as most of the cards are used several times. This selection and return to the file becomes smoother and speedier with practice, so that the examiner can converse with the child between choices if advisable, and the child is less likely to be distracted by the mechanics of the process. These details of construction of the test and of technique in presentation have been given in order to make possible more valid comparisons in case anyone is in a position to try out the test further.

The subjects were nearly all from a nursery school and ranged from three years, one month to five years, five months of age. In addition, 8 children from a public school kindergarten were tested ranging four years, four months to five years, eight months. It is possible that the nursery school children, who had been frequently subjects for various psychological tests, may have been trained thereby to take a better test attitude. It is also possible that they represent a slightly higher selection as regards social status and intelligence than the kindergarten subjects. The 8 kindergarten I.Q.'s ranged from 87 to 121 (median 110), while the nursery school group I.Q.'s ranged from 87 to 158 (median 116). These I.Q.'s are all from Binet tests. I.Q.'s were avail-

able for 37 of the 39 subjects completing the test.

When giving the test, each response was scored as right, wrong, or "color blind," the last being when the number chosen was that which a color blind person would read according to the Ishihara booklet of instructions. A rough scoring system was adopted for the modified Ishihara test as follows:

- 2 plus credits for each correct choice
- 1 plus credit for each mistake *spontaneously* corrected at once by the child
- 2 credits deducted for each color-blind choice
- 1 credit deducted for each wrong choice

Adding these plus and minus credits gave a single number for each child, which was regarded as representing his level of achievement in this color test.

In scoring Plates X and XI where no choice could be considered correct since only a color-blind person is supposed to be able to see a number there, no plus credits could ever be given, but in accordance with the scoring scheme, 2 credits were deducted when the child indicated the color blind choice. Naturally, as a result of the examiner's attitude that a choice was to be made in matching Plates X and XI, practically every child indicated some card as a choice. However, their behavior while doing so was most interesting. Some said plainly at first that they could "see nothing there," or that this one was "hard to see;" then as the examiner said nothing, they would make their choices, usually indicating number 74, which was the most intricate appearing of the numbers in that series. Those who made the color-blind choice, however, (9 cases for Plate X, and 14 cases for Plate XI) usually did so promptly and without expressing any doubt by word or look, or giving any indication that this number was any harder to see than any of the others. There were 18 children who made color-blind choices for Plates X and XI. Five of these made color-blind choices for both plates; 13 for only one. However, only 1 of the 18 expressed doubt or said that the number in question (color-blind choice) was hard to see; while 17 out of the rest of the group (which did not match the color-blind numeral with Plates X and XI) said definitely that this one was "hard to see" or that they "couldn't see it," 1 saying there was "no number there," and 1 that "no one could see it."

If the total score is considered as a rough index of each child's level of achievement in this color test, it is interesting to see what relation exists in this group between total score and such factors as sex, chronological age and mental age.

There were 27 boys and 12 girls in the entire group, which of course is too small a number from which to draw conclusions as to sex differences. However, the range of scores was the same for both sexes, from minus 4 to 22 (perfect score). The median score for the boys was 16 and the median score for the girls was 14. The group of girls averaged younger, as it included only 1 kindergargten child, while there were 7 boys from the kindergarten. This fully accounts for the slightly lower median score of the girls; but there is certainly no indication that the

girls did better on the test than the boys. The results point to no sex difference.

The relation between chronological age and score and that between mental age and score is important, because if we find a closer relation between C.A. and color achievement than that between M.A. and color achievement, it may be interpreted as pointing to 2 things: (1) positively, that the increased efficiency in color vision is more a function of C.A. than it is dependent on M.A. and (2) negatively, that this particular color test is not too dependent on the child's intellectual level, but is really a measure of another capacity, viz. color vision. Computing the correlation coefficients gave the following result:

	r	PE_r
Correlation C.A. with color score	.403	.080
Correlation M.A. with color score	.20	.090

PE_{diff} = .13 indicating 77 chances in 100 that the true difference is greater than 0. The following graph of median scores for each level of M.A. and C.A. indicates that the color test score is more dependent upon C.A. than upon M.A.

While on the subject of age as affecting achievement in this color test, the ages of 4 children who could not do the test at all are worth mentioning. These children were all cooperative in the "game," but all failed in the preliminary test of matching black and white numbers. Their age records are given in table 2. On the other hand, only one child under three years, seven months C.A. could do the test. He was three years, one month with a M.A. of three years, eleven months, which also happened to be the lowest M.A. of any in the group who succeeded. The 4 children referred to above who could not do the preliminary test may have had enough color ability to make a low score on the test, but they appeared not to have the ability to perform reliably in the multiple choice matching situation.

It was possible to retest 6 of the nursery school children after an interval of about a year. There were 3 girls and 3 boys among those retested. Table 3 gives the results.

TABLE 2

	C.A.	I.Q.	M.A.
1	2–3	121	2–9
2	2–9	?	?
3	3–1	120	3–9
4	3–4	100	3–4

TABLE 3

	1ST SCORE	2ND SCORE	GAIN IN POINTS	1ST C.A.	2ND C.A.
Boy 1	20	20	0	4–2	5–1
Girl 1	17	18	1	4	4–11
Girl 2	18	22	4	3–11	4–10
Boy 2	5	20	15	3–7	4–6
Girl 3	2	18	16	3–7	4–6
Boy 3	9	14	5	3–1	4–

A glance down the column of points gained shows a negative correlation between age and gain in points. The 3 oldest had high scores on the original test and hence there was less room for improvement. Boy 3 was the youngest child in the whole group. His gain of 5 points in the year brings him just

to the group median for his C.A. level at four years. So far as it is possible to judge from this small number of retests after a long interval, the amount of gain is less where the orignal performance was high, and the score obtained on the second text is about what would have been predicted (on the basis of the group median) for a child at that age level.

One child was given the color test 3 times within a month. He was four years, eleven months on the date of the first test and his I.Q. of 104 would have given him a M.A. of five years, two months. According to the group medians he might have been expected to make a score of 17 or 18 points. However, on the first test he made only 2 correct choices, which, with 5 wrong choices and 4 color-blind choices, would have given him the score of minus 9. There was some doubt that he had a fair chance, as the first test was given on a partly cloudy day. On a second test on a sunny day he did somewhat better, making 4 right choices, 5 wrong choices and 2 color-blind choices; which would net him a score of only minus 1. He seemed perfectly satisfied with every wrong choice, and used color names freely in talking about the cards, though the color names used were wrong more often than right. On a third test made about three weeks later, he showed some further improvement, making 6 right, 3 wrong and 1 color-blind choices, or a total score of 7. It is interesting to note that the 4 errors on this third test were on cards on which he also made mistakes on the first and second tests. In respect to these 4 mistakes, at least the test proved consistent with repetition. These cards, viz. Plates V, VI, VIII and XII, if the Ishihara interpretation is followed, do not give any clear picture of the type of color weakness which this subject might be supposed to have had. For instance, Plate V is supposed to be read as 21 by the color blind, but only on the first test did this boy choose 21, while on the other two tests he merely made wrong or irrelevant choices. Plate XII he matched once as the "red-blind" are supposed to; and the other 2 times as the "green-blind" are expected to do. Finally, in the case of Plates X and XI, in which the normal see nothing while the color blind are expected to discern a number, this boy did not make a single color-blind choice in any of the 3 tests.

The discussion of this case raises the question whether there is any reliance at all to be placed in the Ishihara test as a means of getting at "types" of color weakness, at least with children. Is it necessary to assume that the mistakes which children make in color matching would necessarily duplicate or even resemble the mistakes which a color blind adult would make on the same test? It may be more reasonable to suppose that the errors made by children who will soon have full color discrimination will be both different from and less consistent than the errors made by a true color-defective.

At any rate, it is a fact that as far as this group of children is concerned, there was not one whose errors gave a consistent picture of any type of color blindness as classified by Ishihara. In other words, not one child made all the

errors which would make it possible to classify him as "red-blind" or "green-blind." Furthermore, no two children made the same combination of wrong choices, if we exclude those making only one error on the whole test. Apparently children of incompletely developed color sense make mistakes which are less schematic and less easily divided into types than might be hoped by proponents of the various schools of color theory. Hayes (1) may be cited as one authority who believes it possible that all types of color defect may have to give way to color charts of every individual's ability:

"The wide diversity of opinion upon the question of the classification of color defectives may be partly explained on the basis of rival color theories; but a second factor of great importance is the enormous individual differences in the subjects studied, making it seem almost equally reasonable to class some subjects in either of two groups . . . . . One wonders if we shall presently have to give up all classification by types, arrange color defectives in distribution tables and give a color graph or profile for each subject showing his efficiency or deficiency for each color in terms of a percentage of the normal or average attaiment."

From another point of view, the number of errors made by these children with each card of the Ishihara test show which cards were hardest and which easiest for them to match. The number of errors made with each Ishihara plate is as follows:

	Errors
Plate II	3
Plate III	3
Plate IV	16
Plate V	17
Plate VI	10
Plate VII	9
Plate VIII	10
Plate IX	5
Plate X	9
Plate XI	14
Plate XII	9
Plate XIII	7

The largest numbers of errors occurred with Plates V, IV and XI respectively. The fewest errors occurred with Plates II, III, and IX.

Finally, the fact that each response was timed by a stop-watch, both in the preliminary test with all black numbers and in the test proper with colored numbers, gives us a measure of what effect the introduction of color had on the length of time the children required to match each number. It was found that the central tendency was for the group to take nearly two or more times as long to match a colored number as to match the same number when it was black on a white

TABLE 4

	No. 2	No. 5	No. 6	No. 7	No. 8	No. 12	No. 26	No. 42	No. 74
Median Black...	3.3	3.0	3.0	3.0	2.6	3.5	3.7	3.5	2.8
Median Color...	6.7	9.2 7.8	5.5 5.3	5.6	4.4	8.2	7.6	6.0	9.2
Med. Dev. Black...	1.8	1.5	1.0	1.1	0.9	1.1	1.6	1.1	1.0
Med. Dev. Color...	3.5	4.4 3.9	2.3 2.3	3.0	2.0	3.7	4.1	2.9	4.8

Where two medians and median deviations are given for one number, it indicates that that digit appears twice on the Ishihara plates.

background. The median times in seconds for the uncolored and colored numbers are given in table 4.

With all the digits the children tend to take longer to match colored numbers than black numbers. Furthermore, as the median deviations show, the variability in time was much greater in the case of the colored cards than with the black and white cards.

SUMMARY

1. An adaptation of the Ishihara Test for color blindness proved applicable to a group of children between the ages of three and one-half and six years.

2. The adaptation consisted of a matching test in multiple choice form, the child being required to pick from a series of 4 cards in each group, the numbers matching those on the Ishihara plates. A similar preliminary test with black instead of colored numbers was given to show the child's ability to deal with matching numbers in a multiple choice form of test.

3. The results with this group of children showed

a. No sex difference in color discrimination.

b. A closer relation between C.A. and total score on the color test, than that between M.A. and test score.

c. Only one child under three years, six months C.A. and no child under three years, eleven months M.A. could do the test.

d. A few retests after one year gave scores approximately as high as would have been predicted for the age level of the child on the second test.

e. Three retests of one child within a month showed a slight practice effect, but a strong tendency to make the same errors in all 3 tests.

f. No child's record corresponded to the types of "color blindness" as defined by Ishihara.

g. No two children made the same combination of errors, excluding those who made only one wrong choice in the test.

h. The largest number of errors occurred with Ishihara Plates V, IV and XI respectively.

i. The fewest errors occurred with Plates II, III and IX.

j. The group took about twice as long to match each colored number as to match the same number in black. The median deviations were about twice as great for matching the colored cards as for matching the black and white cards.

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A Comparative Study of Finger Tapping in Children and Adults[1]

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IN A previous investigation,[2] in which the arms of the subjects were unrestrained, the authors discovered a marked tendency for maturity of performance in tapping to be positively related to the size of muscle-group involved. When pencil, stylus, and three forms of finger tapping were compared an order of functional development from large to small muscle-groups was clearly manifested. The purpose of the present experiment is to discover whether these differences in functional development are more clearly discernible in finger tapping when the hand and arm movements are controlled.

The method employed was finger tapping on the Comptometer with the hand and wrist restrained. A hand-rest, about four inches wider than the key board of the Comptometer was constructed. The rest was covered with black velvet cloth and had two canvas straps for fastening the hand or hands to the rest. The hands were secured, palm downward, with the fingers projecting freely over the first row of the Comptometer keyboard. Adjustments for height and nearness to the keys were possible. This arrangement gave free play to finger movements, restrained all hand movements and reduced arm movements to a minimum. This arrangement necessitated practically independent finger movements when tapping with a single finger.

The index, middle and little fingers of each hand were employed separately for unimanual tapping. For the bimanual tapping the same fingers were used, like fingers of both hands operating simultaneously. Thirty kindergarten children ranging in age from four years, ten months to five years, eleven months, and 30 University students served as subjects. The sexes were approximately equally divided in each group (16 males and 14 females).

The time limit for each trial was 10 seconds in each kind of tapping and was the same for both children and adults. For determining reliability, by the test-retest method, there was a second trial on a different day for each subject. Usually the two trials occurred on successive days, and in no case was the interval between tests more than

[1] From the Psychological Laboratory and the Institute of Child Welfare, University of Minnesota.

[2] A report of a comparative study of several methods of measuring speed of tapping in children and adults, by the authors is to appear in the Journal of Genetic Psychology.

seven days. One complete series for each subject was completed at a single sitting.

In testing both the kindergarten children and the adults the procedure was first demonstrated by the experimenter, after which a brief preliminary trial was given to familiarize the subjects with the task. Directions to the children were practically the same as cited in the writers' preceding paper on tapping with the exception that the subjects were informed that their hands would be fastened to prevent the hand and arm from moving, but that this restraint would not hamper movements of the fingers. The order of unimanual testing was: index finger of right hand, index finger of left hand, middle right, middle left, little right, and little left. A brief rest period was allowed between successive trials. When the unimanual testing was completed the bimanual series was executed in the same order.

Coefficients of reliability for the finger tapping were computed for the separate fingers in both unimanual and

TABLE I

Reliability coefficients of finger tapping on the comptometer by children and adults

KIND OF TAPPING	SINGLE TRIAL		TWO TRIALS (S-B FORMULA)	
	Children	Adults	Children	Adults
Unimanual tapping:				
Right index finger	+.73	+.74	+.84	+.85
Right middle finger	+.30	+.37	+.56	+.54
Right little finger	+.78	+.42	+.88	+.59
Left index finger	+.42	+.22	+.50	+.36
Left middle finger	+.44	+.51	+.61	+.68
Left little finger	+.41	+.63	+.58	+.77
Total right hand	+.63	+.61	+.77	+.76
Total left hand	+.50	+.54	+.67	+.70
Total unimanual	+.65	+.60	+.79	+.75
Bimanual tapping:				
Right index finger	+.55	+.78	+.71	+.88
Right middle finger	+.37	+.66	+.54	+.80
Right little finger	+.40	+.50	+.57	+.67
Left index finger	+.46	+.64	+.63	+.78
Left middle finger	+.40	+.59	+.57	+.74
Left little finger	+.47	+.47	+.64	+.64
Total right hand	+.55	+.71	+.71	+.83
Total left hand	+.74	+.53	+.85	+.69
Total bimanual	+.69	+.64	+.82	+.78
Grand total—both hands	+.76	+.76	+.86	+.86

bimanual tapping by correlating test with retest scores. In addition, the reliability coefficients of the combined scores for each hand, for each method, and for the grand total were ascertained. As the intercorrelations in this investigation were computed by the use of combined scores for the 2 trials, the Spearman-Brown formula was used to obtain the reliability of scores on trial 1 plus scores on trial 2. All correlations were calculated by the Pearson product-moment method. Table 1 gives the reliability coefficients.

For a single trial, all but 4 coefficients of reliability are higher than +.40, the range being +.22 to +.78. For the 2 trials summed the range is +.36 to +.88. In general, the reliability of tapping tends to be slightly higher for children in unimanual tapping, and somewhat higher for adults in bimanual tapping. The higher reliability of bimanual tapping with adult subjects can be explained in part by the fact that the children, in this kind of tapping, looked at and apparently devoted their attention to one hand almost entirely, or switched their fixation alternately from one hand to the other. The totals in unimanual and in bimanual tapping have slightly higher reliabilities for children, but the grand total is equally reliable for children and adults. (Single score +.76; summed scores +.86). In the case of adults, the index finger is most reliable in 3 of 4 determinations; with children there is no consistent trend but the right index finger and right little finger in unimanual tapping have comparatively high reliabilities.

In table 2 are given the means and the standard deviations of the separate trials for tapping rate of children and adults. The table also shows the ratio between the means of the children and of the adults, i.e., the proportion of the average speed of adults that has been attained by the children in each kind of tapping.

Examination of the mean scores given in the first four columns of figures reveals the following trends: (1) With children there is a marked practice effect in finger tapping. (2) Adult tapping scores show no practice effects. The second score is frequently smaller than the first. (3) With both the child and the adult group the index and middle fingers yield tapping scores which are nearly equal to each other in magnitude. In some cases the middle finger taps faster, in other cases the index finger. (4) The tapping speed of the little finger is much slower than that of the other fingers, particularly in the child group. (5) Bimanual tapping is slightly slower than unimanual tapping for both groups. (6) Speed of tapping with fingers of the left hand is slower than with fingers of the right hand.

The standard deviations given in the fifth to eighth rows of table 2 show that, in the unimanual tapping of children, performance of the middle finger is least variable. Also the variabilities of tapping scores for the little finger are relatively very high, especially in the case of children.

The last two columns of table 2 reveal an interesting developmental trend in the comparative maturity of the various muscle groups involved in the tapping movements. As seen in the first row, in tapping with index

finger, the children have attained 41 per cent of adult efficiency on the first trial and 46 per cent on the second. These last two columns of the table show the following trends: (1) In *every instance but one the order of* comparative maturity of performance is middle finger first, index finger next and little finger last. (2) The index and middle fingers maintain about the same levels of comparative efficiency throughout the series. (3) There is a greater group difference in maturity of tapping in case of the little finger than with the other two fingers. (4) On the second trial the children are always closer to the adult level than on the first. (5) The comparative

TABLE 2

Means and standard deviations of number of taps in ten seconds by children and adults for finger tapping on the comptometer

KIND OF TAPPING	MEAN SCORE				STANDARD DEVIATION				MEAN SCORE	
	Children		Adults		Children		Adults		Ratio: child to adult	
	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
Unimanual tapping:										
Right index finger	22.9	24.0	55.5	54.3	5.1	5.5	6.0	6.5	.41	.46
Right middle finger	23.6	25.1	54.5	52.0	3.3	3.8	5.0	3.7	.43	.47
Right little finger	9.0	12.2	44.0	42.3	6.5	8.0	6.5	7.0	.22	.29
Left index finger	22.2	23.5	50.3	49.0	4.5	3.9	6.3	3.7	.44	.47
Left middle finger	22.0	24.3	49.3	49.8	3.7	3.6	4.5	5.6	.45	.49
Left little finger	7.8	10.9	40.8	40.5	5.8	5.0	5.4	5.6	.19	.27
Total right hand*	55.2	61.3	153.7	149.6	10.2	12.8	12.0	11.5	.36	.41
Total left hand	50.7	57.0	140.0	138.8	9.8	9.8	13.7	11.0	.36	.41
Total both hands	105.5	117.8	293.3	287.8	18.4	20.7	23.1	19.8	.36	.41
Bimanual tapping:										
Right index finger	22.0	25.6	52.5	50.3	5.8	4.5	6.7	6.7	.42	.51
Right middle finger	22.7	23.9	52.7	49.5	4.8	4.0	6.3	7.8	.43	.48
Right little finger	6.5	9.5	42.8	39.1	5.8	5.6	6.8	7.6	.15	.24
Left index finger	20.5	23.0	50.1	49.3	6.5	4.5	6.2	6.7	.41	.48
Left middle finger	20.8	22.8	47.8	46.3	6.1	4.9	7.1	7.9	.42	.49
Left little finger	5.4	8.1	37.5	36.6	4.5	5.5	8.0	6.9	.14	.22
Total right hand	49.9	57.6	147.0	137.1	13.1	10.7	14.4	16.8	.34	.42
Total left hand	46.6	53.3	134.5	131.5	13.8	11.7	15.6	16.4	.34	.41
Total both hands	96.4	111.3	281.6	269.9	24.8	21.3	27.0	30.7	.34	.41
Grand total—both hands	201.3	228.0	577.0	556.3	37.4	39.9	41.4	46.5	.35	.41

* All averages and standard deviations are computed from original scores.

maturity of performance for the total of right hand, of left hand, and of both hands is the same (36 per cent in unimanual and 34 per cent in bimanual tapping. (6) Finger tapping of children approaches nearest adult proficiency when the middle finger is used (49 per cent on the second trial).

In our previous study of finger tapping with the arm unrestrained, the developmental trend in comparative functional maturity revealed the children to be nearest adult proficiency with the index finger. The middle and little finger than followed in order. Both the first study and the present investigation reveal about the same trends in scores for the different fingers, i.e., scores for index and middle fingers are about equal in each kind of tapping, but in only 5 of 16 instances are the scores for the index fingers higher than those for the middle fingers. The developmental tendency in comparative functional maturity revealed in the present experiment (middle finger nearest adult maturity, then index finger and then little finger) is probably approximately correct since arm movements have been controlled in this study. One should emphasize the fact, however, that the difference in functional maturity between the middle finger and index finger is slight.

Table 3 shows the intercorrelations of the scores in finger taping for each of the 2 groups of subjects. In computing these correlations the sums of the scores for the 2 trials were employed. In the last column of the table are given the correlations between the correlation coefficients for the children and those for adults when each finger under a certain condition is correlated with every other finger under each of the various conditions. Thus when the series of coefficients for children in row one of the table are correlated with the series for adults in row two, a correlation of +.82 is obtained. These coefficients in the last column reveal the extent to which a constant tendency in the relationships between the tapping speeds of the different fingers persists from childhood to maturity. The range of these coefficients is from +.17 to +.88 with an average of +.61. In our previous tapping investigation the range of comparable coefficients was +.22 to +.84 with the average at +.61. In the present study all but two correlations are +.63 or above. This indicates that, although some fingers are more closely related to each other in speed of tapping than others (see rest of table), this relationship does not change greatly with age.

A survey of the first 12 columns of table 3 reveals 11 negative coefficients out of a total of 132. The range of correlations is −.18 to +.84 Method of tapping (unimanual or bimanual) sees to have little influence on the intercorrelations for either children or adults since many of the highest as well as many of the lowest coefficients are found both when similar methods and when unlike methods are involved. Analysis of the correlation coefficients of table 3 reveals the following trends: (1) Any specific finger tends to yield performance which correlates well with performance by the same finger of the other hand, and with performance by the same finger in another method (unimanual or bimanual); (2)

Tapping scores of the index fingers yield a fair correlation with those of the middle fingers; (3) scores of the little fingers show little or no correspondence to scores of either of the other fingers. In our previous study the relationship between the more nearly adjacent fingers tended to be closer than that between fingers more widely separated.

TABLE 3

Intercorrelations between scores on finger tapping for children and for adults

	U-R INDEX	U-R MIDDLE	U-R LITTLE	U-L INDEX	U-L MIDDLE	U-L LITTLE	B-R INDEX	B-R MIDDLE	B-R LITTLE	B-L INDEX	B-L MIDDLE	B-L LITTLE	r BETWEEN GROUPS
U-R* Index:													
Children.....		+.50	+.26	+.71	+.44	+.45	+.73	+.54	+.33	+.47	+.48	+.25	+.82
Adults.......		+.40	+.07	+.62	+.32	+.05	+.57	+.31	−.02	+.47	+.15	−.06	
U-R Middle:													
Children.....	+.50		−.17	+.48	+.59	−.06	+.28	+.48	−.09	+.22	+.37	−.06	+.85
Adults.......	+.40		+.01	+.53	+.62	+.04	+.38	+.59	+.17	+.40	+.47	−.07	
U-R Little:													
Children	+.26	−.17		+.10	+.03	+.70	+.31	+.33	+.73	+.44	+.20	+.58	+.02
Adults.......	+.07	+.01		+.11	+.17	+.08	+.13	+.25	+.62	+.13	−.07	+.17	
U-L Index:													
Children.....	+.71	+.48	+.10		+.55	+.39	+.51	+.40	+.14	+.52	+.48	+.07	+.88
Adults.......	+.62	+.53	+.11		+.07	+.43	+.78	+.62	+.23	+.57	+.59	+.10	
U-L Middle:													
Children.....	+.44	+.59	+.03	+.55		+.12	+.19	+.52	+.01	+.28	+.65	.00	+.83
Adults.......	+.32	+.62	+.17	+.67		+.48	+.47	+.42	+.28	+.58	+.68	+.22	
U-L Little:													
Children.....	+.45	−.06	+.70	+.39	+.12		+.44	+.29	+.70	+.62	+.42	+.68	+.17
Adults.......	+.05	+.04	+.08	+.43	+.48		+.31	+.23	+.40	+.48	+.45	+.66	
B-R Index:													
Children.....	+.73	+.28	+.31	+.51	+.19	+.44		+.54	+.37	+.72	+.41	+.34	+.69
Adults.......	+.57	+.38	+.13	+.78	+.47	+.31		+.76	+.15	+.84	+.55	−.02	
B-R Middle:													
Children.....	+.54	+.48	+.33	+.40	+.52	+.29	+.54		+.37	+.53	+.72	+.28	+.64
Adults.......	+.31	+.59	+.25	+.62	+.42	+.23	+.76		+.34	+.52	+.51	−.04	
B-R Little:													
Children.....	+.33	−.09	+.73	+.14	+.01	+.70	+.37	+.37		+.34	+.39	+.68	+.66
Adults.......	−.02	+.17	+.62	+.23	+.28	+.40	+.15	+.34		+.07	+.25	+.57	
B-L Index:													
Children.....	+.47	+.22	+.44	+.52	+.28	+.62	+.72	+.53	+.34		+.59	+.34	+.54
Adults.......	+.47	+.40	+.13	+.57	+.58	+.48	+.84	+.52	+.07		+.54	−.18	
B-L Middle:													
Children.....	+.48	+.37	+.20	+.48	+.65	+.42	+.41	+.72	+.39	+.59		+.36	+.64
Adults.......	+.15	+.47	−.07	+.59	+.68	+.45	+.55	+.51	+.25	+.54		+.27	
B-L Little:													
Children.....	+.25	−.06	+.58	+.07	.00	+.68	+.34	+.28	+.68	+.34	+.36		+.63
Adults.......	−.06	−.07	+.17	+.10	+.22	+.66	−.02	−.04	+.57	−.18	+.27		

* U = unimanual; B = bimanual; R = right; L = left.

Twenty-three of the kindergarten

children in this experiment had also served as subjects on the earlier study in which the arms were unrestrained. An interval of three months elapsed between experiments. Intercorrelations between tapping scores made with arms restrained and with arms unrestrained are given in table 4. The coefficients indicate that there is only a small amount of correspondence present between performance under the 2 conditions. The coefficients range from +.09 to +.75 with a correlation of +.45 for the grand total.

TABLE 4

Comptometer tapping with arm unrestrained vs. comptometer tapping with arm restrained (children only)

FINGER AND HAND USED	UNIMANUAL TAPPING	BIMANUAL TAPPING
Right index	+.27	+.36
Right middle	+.31	+.47
Right little	+.25	+.25
Left index	+.75	+.09
Left middle	+.51	+.45
Left little	+.24	+.36
Total right hand	+.15	+.49
Total left hand	+.07	+.30
Total both hands	+.33	+.45

Grand total—bimanual plus unimanual, r = +.45

SUMMARY

1. The rate of finger tapping was measured for a group of 30 kindergarten children and for 30 college students.

2. Arm movements were restrained by securing the hand, palm downward, on a hand rest, in such a manner that the hand was immovable and the wrist and arm movements were reduced to a minimum. The fingers were entirely free from restraint.

3. A Comptometer was employed to measure the speed of tapping. The index, middle, and little fingers of each hand were tested independently (unimanual tapping) and simultaneously (bimanual tapping).

4. Reliabilities were computed by correlating test with retest scores. For the single fingers there was a tendency for the tapping scores to be more reliable for children in unimanual and for adults in bimanual. The totals for both unimanual and bimanual tapping are slightly more reliable for children than adults, but the grand total is equally reliable for both children and adults. (Single score, +.76; summed scores +.86).

5. In both the child and the adult group the index and middle fingers yield tapping scores approximately equal in magnitude. Tapping of the middle finger was only a little faster than that of the index finger. The little finger taps at a much slower rate than the other fingers. Right hand tapping is slower than left, and bimanual tapping is slower than unimanual.

6. When the children are compared with the adult group the order of comparative maturity of performance is middle finger nearest adult maturity, index finger next and little finger last. The comparative maturity of performance for the total of right hand, total of left hand, and of both hands together is the same (34 per cent).

7. Although some fingers are more closely related to each other in speed of tapping than others, this relation-

ship does not change greatly with age. (Average correlation between coefficients for children and adults is +.61).

8. Tapping by any finger tends to correlate well with tapping by the same finger of the other hand or tapping by the same finger in another method (unimanual and bimanual).

9. Tapping scores of the index and middle finger tend to correlate more highly with each other than the scores of either of these fingers with the scores of the little finger.

10. There is a small degree of correspondence between scores for finger tapping with arm and hand restrained and scores with arm and hand unrestrained in the case of the children.

Motor Suggestion in Children

Roberta Stevens White

THE term suggestion has been used to cover such a wide variety of phenomena that it is necessary to define carefully the type under consideration and differentiate it from the other uses of the term. A rough classification of the various definitions may be made under the three headings of sensory, ideational, and motor suggestion. Sensory suggestion seems to mean merely illusions of sensation occurring under some special condition of expectancy, emotion, or the like. Ideational suggestion is clearly stated in MacDougall's (23) classic definition, "Suggestion is a process of communication resulting in the acceptance with conviction of the communicated proposition in the absence of logically adequate grounds for its acceptance."

Motor suggestion, the type with which this study deals, is more difficult to define concisely. Baudouin (2) characterizes it as "the automatic activation of an idea;" Hilger (12) as "the dynamic nature of ideas." Morgan (24) makes the statement that "every idea of an action will result in that action unless hindered by a competing idea or physical impediment." Hartenburg (11) names this active suggestion or "the excessive impulsiveness of ideas."

Some writers, among them MacDougall (23), do not call this suggestion at all, but class it as simple ideo-motor activity, or unconscious imitation. Dunlap (8) objects to this terminology and substitutes the phrase "similitude reactions" which are "sometimes said to be unconscious imitations, but such is not really the case. They are not reflective it is true; they are unintentional; but there is perceptual consciousness involved in each one of them." Ladd and Woodworth (17) deal with the question of the unconscious nature of the phenomenon in a clear and objective way: "Certain ideas lead to certain definite movements with which they have become associated by past experience. They may do so either with or without the full consent of the subject. When an idea leads to its appropriate movement with the full consent of the subject, we call it voluntary movement, but when the idea leads to movement, as it always tends to, while the subject's attention and intention are elsewhere directed, the movement is often named ideo-motor." There is thus a graduated scale from wholly conscious purposive imitation to, at the other extreme, the involuntary carrying out of a suggestion of which one is more or less unconscious, acting as an automatom. This might equally as well be called involuntary imitation or any one of the other dozen names which have been applied to it.

The definition of Ladd and Wood-

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worth (17) contains an adequate theoretical explanation. Ideo-motor activity is a specialized type of habit formation in which the act is more or less involuntary and outside the focus of attention. Humphrey (13) upholds the same view, though he interprets imitation in terms of the conditioned reflex, saying it "may be defined as action involving a conditioned reflex the secondary stimulus of which is similar to the reaction." He adds that these relatively elementary and unconscious units of imitation form a part of a larger and undoubtedly conscious system. It is the isolation and measurement of such simple elements of action in the young child that this study aims to achieve.

PREVIOUS EXPERIMENTS WITH ADULTS

The bulk of experimental work dealing with suggestion has been carried on with adult subjects. A large part of this treats only sensory and ideational suggestion, which do not concern us here. The first study of motor suggestion was Jastrow's (14) experiment in 1892. He devised an automatograph to record the involuntary motion of the hand and head. His results show movement toward the object of attention and oscillation with the beat of the metronome or pendulum. Solomon and Stein (32) used a planchette whose action was similar to that of the automatograph. They found a general tendency to involuntary movement as soon as the attention of the subject was removed. They were able to develop a high degree of proficiency in automatic writing, which they explain as the unconscious passage of sensation into motor reactions.

Pearce (27) investigated the motor response to dermal, auditory, and visual stimuli, asking the subject to localize a stimulus, at the same time giving a second one near the spot where the first had been. It was found that this second stimulus or suggestion caused an error in localization varying with its intensity and distance from the first.

Brand (6) studied the effect of verbal suggestion upon the estimation of linear magnitudes, concluding that purely formal and arbitrary suggestion produces a definite though slight effect. Smith and Sowton (31) report the same results. Bell's (3) work was similar, showing the effect of suggestion on the reproduction of triangles and point distances. Both auditory and visual suggestions were used. There were decided individual differences in susceptibility to suggestion. Jones (16) found that suggestions of ability and inability also influenced reproduction of distances. Variability and error were less with affirmative than with negative suggestion, but least of all with no suggestion.

Strong's (34) work dealt with the effect of suggestion on muscular activity measured by the dynomometer. He found that suggestion as a whole heightens the maxima above neutral, the negative more so with some subjects and the positive with others. In comparing his results with those of Jones, Strong points out that suggestion hinders when accurate work is to be done, but helps when mere amount of muscular effort is wanted.

Starch (33) in his study of unconscious imitation of handwriting, 1911, was the first to use a large group of

subjects. One hundred and six students wrote words and sentences from copies of different kinds if handwritten and typed material. Three of the subjects purposively imitated the copy. Their results were discarded. All of the remaining 103 subjects showed a change in size and slant of their writing in accordance with the type of material copied. The men showed a greater tendency towards imitation than the women.

Langfeld (18) has studied the effect of positive and negative instructions on voluntary movement. The negative method is supposed to be a suggestion towards poorer work. He used a tracing board with both types of instructions. In general his results show that the best work is done with positive instructions, though great variability exists.

PREVIOUS EXPERIMENTS WITH CHILDREN

The experimental work dealing with child subjects falls naturally into two chronological divisions. Binet (5, 6) and the other workers at the beginning of the century were chiefly concerned with devising tests to measure the trait called suggestibility, and applying them to children in the hope of finding individual and age differences. Since 1920, however, the trend has been away from individual measures towards the use of a battery of tests in attacking some specific problem, either theoretical or practical, in the field of suggestion.

Practically all of the earlier tests dealt with sensory and ideational suggestion. Otis (26) has summarized a number of these. Most of the results agree in indicating an inverse relationship between age and suggestibility as measured by this type of test.

Very few tests of motor suggestion have been applied to children. Jastrow (14) in his original work with the automatograph used one child subject, a boy of eleven who showed extensive and coarse movement. With the same apparatus Tucker (36) made a comparison of the involuntary movements of 18 adults and 25 children. He found no definite tendency to move toward a seen object if it was thought of as at rest. A moving stimulus produced imitative movements in the direction of its motion. Children were subject to these laws to a less degree than adults. No sex or age differences among them were discernable.

Binet (4) contributed several ingenious tests of motor suggestion. Two he classed as experiments on subconscious movements. The child passively held one end of a balance which the examiner moved in rhythm with the beats of a metronome. This movement was gradually discontinued and in many cases the child would carry it on automatically. In a similar manner Binet attempted to produce automatic writing. He remarks that these automatisms do not appear to coincide with automatisms of judgment. Simon (30) repeated the tests on abnormal children using a pendulum. Giroud (10) used Binet's methods but gives no results. A second type of motor suggestion is tested by Binet as "submissive imitation." The children are studied in groups to find the extent to which they will imitate the words and drawings of others. Binet also describes several types of automatisms

which he investigated but did not develop as tests because they revealed little in the way of individual differences. One of these was similar to a method used with preschool children in this study. Subjects were asked to make a circle exactly three centimeters away from one which was drawn on a sheet of paper. The tendency to make the second equal in size to the first was almost universal.

In more recent years tests of motor suggestion have been developed by various authors and used in batteries for the investigation of some specific problem. Sherman (29) reports 2 in her study of the relative suggestibility of normal and mentally defective children. One showed the effect of pointing arrows in tracing a path, the other the effect of pointing hands upon choice. The results indicate that "both normal and mentally defective children were suggestible in all of the tests used, and that in both groups of subjects suggestibility was related to their development."

Aveling and Hargreaves (1) conducted a series of tests to study the effect of personal prestige on suggestion. Five of the tests dealt with sensory and ideational suggestion and are described in Whipple's manual (38). In addition there were 2 tests of their own invention, Hand Rigidity and Hand Levitation. In these the experimenter used verbal instructions to induce an affect of rigidity or of lightness in the hand of the subject. These last two tests, together with the illusion of warmth test and line lengths by personal influence, were situations in which personal prestige was the most conspicuous element. In the three other tests the personal factor was at a minimum and suggestion was of the "non-prestige type." It was found that the frequency distributions of scores varied in accordance with the type of test. Those tests in which the prestige factor was low gave a normal distribution, showing that all subjects were suggestible in varying degrees. Those in which the personal factor was dominant presented a "U" type of curve, owing to the development of contra-suggestibility in a number of cases.

Estabrooks (9) interpreted the results of Aveling and Hargreaves (1) in terms of emotion. He believes that the "U" type of curve in prestige tests is the result of the "All or none" principle which responses tend to follow when accompanied by strong feeling tone. If such be the case, suggestibility in this type of test should correlate closely with the psycho-galvanic reflex. To demonstrate this proposition he conducted an investigation on boys whose mean age was 11.5 months. The psycho-galvanic reflex and three tests of suggestibility were used, illusion of an electric shock, material-weight illusion, and a "Bob Test." This was a modified Chevreul's Pendulum. An iron bob on an 18-inch string, which the child held, was hung in a glass tumbler. Suggestions as to its movement were given and the time recorded until it swung enough to touch the side of the glass. This Bob Test and the electricity test were designed to include a strong factor of emotion. The distribution curve of results is of the "U" type. In the material-weight illusion personal influence was eliminated as much as possible. Here a

typical curve of normal distribution resulted. Correlation between the tests and with the psycho-galvanic reflex were negligible. Estabrooks concludes that "in tests for suggestibility we do tend to get the "All or nothing" type of response when strong emotion is concerned, and that the resultant U-curve tends to become normal as this emotional element recedes. This is especially so if it is superceded by an element of intellectual discrimination." He believes that this non-prestige type of reation should be called "illusibility" rather than suggestibility.

This analysis of the experiments on motor suggestion with child subjects shows that practically no work goes below the level of six years. The only exception is Mosse's (25) investigation of the therapeutic value of suggestion on 22 children from three to six years of age. *He gave them a fake medicine* with the suggestion that it would produce immediate urination. In all of the cases the suggestion was effective.

To find material using subjects below school age it is necessary to look to studies of contrary suggestion or negativism. According to MacDougall (22) this converse of suggestibility results when unpleasantness has been connected with the stimulus in the past. Bridges (7) says it is a defense reaction against hyper-suggestibility. If this be true, measures of resistance will be valuable as indications of suggestibility.

Levy and Tulchin (19, 20, 21) made an extensive study of the resistance of infants and children during mental tests. Nine hundred and eighty-three subjects were grouped according to the amount of resistance shown, the *criterion being refusal to take the tests.* The results show a gradual rise from a low level of resistance at six months to a high point at thirty to thirty-six months, then a rapid fall to a low limit from forty-eight to fifty-four months. Nelson, in a report edited by Thomas (35), presents the results of another study of resistance in the mental test situation. The Merrill-Palmer Performance and Kuhlman-Binet tests were given to 28 children whose chronological ages were from eighteen to forty-eight months and mental ages from thirty to seventy-two months. Though the number of cases is small the results point to a definite decrease of negativism with increasing chronological age, mental age, and intelligence quotient.

Reynold's (28) study of negativism bears this out. She used 229 children *from twenty-one to sixteen months in* age, placing them in 13 successive situations where negativistic behavior might be manifested and giving a score of one for each instance where it appeared. Her results show that negativism wanes consistently with age.

PRELIMINARY EXPERIMENTATION

The historical summary makes it clear that very little work of the type classed as motor suggestion has been done on children, especially those of preschool age. This made it necessary to devise tests which would measure this trait, the involuntary translation of a perception into bodily activity.

There were certain conditions which such a test had to fulfill. In the first place the reaction required of the child had to be of such a simple nature that it would be well within the power of a

three year old child to perform, and preferably within the ability of a two year old. If the tests were too difficult, the variations in motor ability among the children would entirely obscure the effects of suggestion. In the second place, the attention of the child had to be distracted as much as possible from the suggestion so that purposeful imitation would be eliminated. Nor should submission to the personality of the experimenter play an undue part. Finally the test must be one to hold the interest of the child.

The 8 experiments which were devised met these conditions more or less successfully. Each was given to a small group of subjects to test its applicability to the problem. All except the last two were found to be unsatisfactory as measures of the trait under consideration and so were not continued in the major study. A brief report of each is given to show the evolution of the technique finally adopted.

1. Tracing path

In her study of motor coordination Wellman (37) makes the statement, based on Langfeld's work, (18) that positive instructions will result in greater success than negative. This seemed to be a clear-cut case of the idea of an action producing that action whether the subject wills it or no. To test this assumption the tracing path test used by Wellman was given to 43 children between the ages of 2:7 and 6:3 years, under the two types of instructions. (Throughout this study age will be so designated in years and months. Thus 2:7 means two years and seven months.) Eighteen of the children took the test 4 times, twice under the positive and twice under negative instructions. Twenty-five took it twice, once with each type of procedure. At least a week's time invened between each test. The order of giving the 2 kinds of instructions was varied with the different subjects so as to minimize the effects of practice. The 2 types of procedure were as follows:

Positive instructions. The child was seated at a table of comfortable height. Before him was placed a sheet of paper on which had been drawn two "tracing paths" (37). These are 2 straight lines 25 cm. in length 5 cm. apart at one end and 1 cm. apart at the other. The sheet was tacked to a card board and so placed that the wider end of the path was at the child's left, making the line to be drawn from left to right. The experimenter picked up a red pencil saying, "See this pencil? I want you to make a mark right down the path with the pencil. Keep right in the middle of the path all the time. Make it look just like this, a nice straight line." The child was then shown a sample perfectly drawn with a red line down the exact center of the path. When he had completed the line the sheet of paper was turned around so the other path was next to him. Its larger end was at the child's right so that the line had to be drawn from right to left. The instructions were repeated as before.

Negative instructions. This procedure was similar to that above except that instead of showing the child a perfect sample the experimenter showed one very poorly done, pointing out the errors with the words, "Don't touch the sides like this or make a wiggly line like this."

Two methods of scoring were tried. The first score was that part of the guide line, measured in centimeters, where the line that the child had drawn was outside the path. The second method was to measure the total length of the child's line with a map measurer, the score being the length in excess of 25 cm. Neither of these methods proved fine enough to discriminate the effect of suggestion if such existed. The difference between the kind of line drawn under positive and under negative instructions was no greater than the difference between the 2 lines drawn with the same instructions.

2. Coördination test

As a check on the effect of positive and negative instructions, the Johnson form of the Johns Hopkins series of coördination tests (15) was used with the same procedure as the tracing path described above, to the same 43 children. The score consisted of the number of errors, that is, the number of times the child's line touched the side of the path. The results were the exact reverse of what was expected. The average number of errors per sheet was 6.3 under positive instructions, and 3.4 under negative.

3. Ladder experiment

This experiment was an attempt to measure the child's tendency towards involuntary imitation in drawing. Twenty children from 3: 6 to 5: 4 years of age were tested in groups of five and six. Each child was seated at a separate table and given a sheet of drawing paper on which had been drawn with black crayon 2 parallel vertical lines 20 cm. long and 8 cm. apart. The experimenter had a similar sheet on an easel where it could be plainly seen by the group. She called their attention to it by saying, "Do you see these 2 lines on my paper just like the 2 lines on your paper? I'm going to make a ladder out of these 2 lines by drawing lines straight across. Watch me (drawing). Now you make ladders with these crayons." The children were then given black crayons and the sample left in view while they were drawing. Three methods of drawing the sample were used, making the rungs of the ladder straight across, that is horizontal, or making them slope to the right or to the left so that one edge of each rung was 2 cm. below the other. The test was repeated three times, a week apart, once with each type of suggestion. The results were not significant. Only 6 out of the 20 children accepted the suggestion, that is, made the slope of their rungs pronounced enough to show that it was not the result of chance error.

4. Drawing pictures

This test was similar to the preceding one, but the suggestion was more obvious. The same 20 children were tested in groups as before. Each was given a sheet of paper and 3 colored crayons of his own choice. The experimenter then said, "When I say 'begin' we are all going to draw pictures. You can make any kind of a picture you want to." One of three variations in procedure followed. In one a picture of a flower was shown with the words, "You can make a flower like this if you want to. Look at this flower, with its yellow center and

colored leaves (pointing at the parts and being sure all the children attend). Or you can make anything else you like." In the second type of procedure no picture was shown but the verbal suggestion was given, "You can make a tree if you want, a nice big tree." In the third no suggestion was given.

The individual results were interesting, but quantitatively they have little value because of the small number of subjects. Of the 20 children 5 accepted the suggestion of drawing the tree, 5 of drawing the flower. This test was discarded because it gave only the number of times the suggestion was accepted and not the extent of the acceptance. There were also various sources of error which resulted from the group administration of the test.

5. Running to get ball

This experiment was designed to show the effect of suggestion on the gross bodily activity of the child. The child was placed behind a low gate at one end of an alley 12 feet long and 2 feet wide. At the other end was a low table with a ball on it, well illumined by a drop light. Three types of procedure were used. That with no suggestion was given first. The child was told to go get the ball, the gate was opened, and the time taken to reach the table was recorded. A week later the experiment was repeated with either fast or slow suggestion. The former consisted of the experimenter first demonstrating by running quickly down the alley to get the ball. In giving the slow suggestion she walked very deliberately to the ball. These procedures were alternated for four successive weeks. Finally on the sixth trial as on the first no suggestion was given.

Twenty-nine children from 2:1 to 4:9 years of age were given the test. In two or three individual cases the suggestion seemed to have an effect in slowing down or speeding up the running. But the average time for the group showed no effect of suggestion. There were several sources of error which may account for these negative results. In the first place the suggestion given was not always attended to carefully. The children were distracted by various things, especially the hinge on the gate which they enjoyed manipulating. The timing was not accurate enough for such a short running path. If it had been several times longer the results might have been more satisfactory.

6. Punching, Form A

This experiment was also designed to test the effect of suggestion on speed of movement. A very simple manual process was chosen, that of punching holes in paper. The child was seated at a table on which was placed a sheet of paper with 16 half-inch circles printed on it arranged in the shape of a square. Under the paper was a pad to facilitate the punching of holes. Three types of procedure were used. In one no suggestion was given. The experimenter said, "Take this puncher and make one hole in each circle like this. Make just one hole in every single circle," illustrating by punching 2 holes in a similar sheet with a sharp pointed stylus. The stylus was then handed to the child with the words, "Now you do it." Time was recorded with a

stop watch from the moment of making the first hole to that of making the last. The 2 other procedures were similar except that in one the experimenter punched all the holes first at a rapid rate, taking about 8 seconds, and in the other at a slow rate, taking about 25 to 30 seconds. The experiment was repeated three times each a week apart with a different type of procedure at each sitting. The order of giving the three methods was varied with the different subjects so that the effect of practice would be minimized. Twenty-four children ranging in age from 4:3 to 6:3 took the test.

The results showed a significant difference between the speed of reaction under the various types of suggestion, average time under slow being 25.3 seconds, under fast 20.5 seconds, and under no suggestion, 24.0 seconds. Of the 24 subjects, 19 punched faster under the *fast than under the slow suggestion*. These results appeared in spite of several sources of error. The arrangement of the circles in the shape of a square resulted in various orders of punching being used. Many of the younger children used no regular order, or varied their method from time to time. Nor was there a record kept of which hand was employed in punching, sometimes the right and sometimes the left being used. The fact that in spite of these faults in procedure the results were positive, indicated that this test merited further *application*.

7. *Punching, Form B*

This modified form attempted to overcome several of the obvious difficulties of Form A. Instead of the 16 half-inch circles printed in the form of a square, 10 were used, placed in a row $\frac{1}{2}$ inch apart on a sheet of paper $4\frac{1}{2}$ by 11 inches in size (fig. 1). The fact that they were in a straight line did away with the element of order of punching except with the very youngest subjects. The experimenter demonstrated beginning at the child's left and most of the children imitated this method. Another source of error was eliminated in *having all the children use the right* hand throughout so that there were no variations in this respect from one period to another. To introduce variety and to maintain the children's interest 2 other types of punching sheet were designed. One-half inch squares and triangles were used in

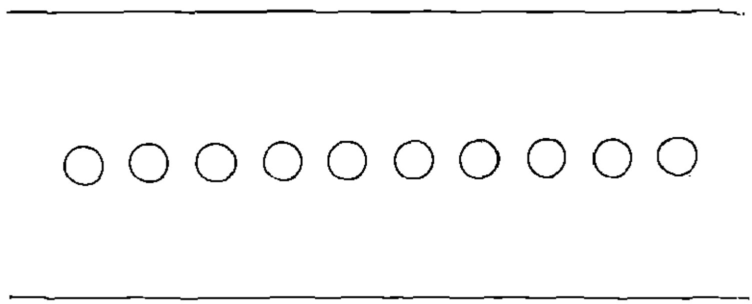

FIG. 1. PUNCHING SHEET

addition to the circles. Few of the children seemed to be affected by this difference. Aside from these changes the procedure was the same as in Form A.

Nineteen children from 3:6 to 5:4 years of age completed this test. The results show a difference of 5.6 seconds in the average time under slow and under fast suggestion: fast, 13.9 seconds; slow, 19.6 seconds; no suggestion, 19.3 seconds. Of the 19 subjects, 16 punched faster under fast suggestion than under slow suggestion.

8. *Marking dog*

The final test devised was one in which the suggestion was of a more obvious nature than in the preceding experiments, and is more closely akin to imitation as ordinarily conceived. Here again 3 types of procedure were used. These were designated by the letters F, S, and N to correspond with the Fast, Slow, and No suggestion of the punching test.

N procedure (no suggestion). A sheet of paper 4½ by 11 inches in size with an outline picture of a dog in the center (fig. 2) was placed in front of the child with the words, "Do you see this doggie? Make a mark on the paper at the side of the doggie." The experimenter then placed a crayon in the child's right hand. When the mark had been made she said, "That's good. Now make a mark on the other side of the doggie." A record was kept of the direction in which the line was drawn.

F procedure ("far" suggestion). The picture of the dog was placed in front of the child as before with the words, "Do you see this doggie? I'm going to make a mark on the paper at the side of the doggie." The experimenter then made a vertical line about 1½ centimeters long, 1 centimeter from the right hand margin of the sheet, and half way between the top and bottom margins. The sheet was then removed exposing a similar one beneath it. The experimenter directed, "Now you make a mark on the paper at the side of that doggie," giving the child a crayon. When he had complied she placed the first sheet again before the

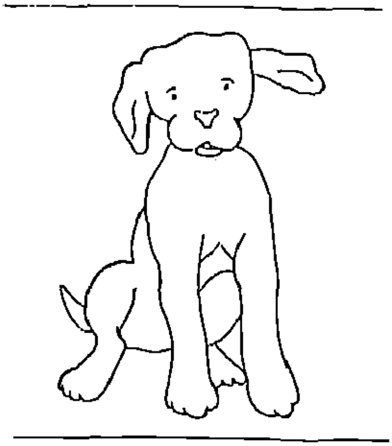

FIG. 2. MARKING SHEET, PRELIMINARY TEST

child and repeated, "Now I'm going to make a mark on the other side of the doggie," making a line at the margin of the paper to the left of the dog. This sheet was again removed and the child told, "Now you make a mark on the other side of that doggie."

S procedure ("short" suggestion). This was similar to the F procedure except that instead of making the mark at the margin of the paper the experimenter drew it one centimeter from the side of the dog.

The distance of the child's marks from each side of the dog was measured in centimeters and the two added. Twenty-nine children from 2:1 to 4:9 years of age took the test. Several did not complete the series, and 5 of the younger ones merely scribbled, so that the data from only 18 are considered. The subjects were divided into 2 groups equated as nearly as possible on the basis of age and sex. Six test periods were used, at least six days apart. N procedure was used at the first and last of these periods for both groups. One group was tested by the F procedure at the second and fourth periods, and by the S procedure at the third and fifth periods. In the other group this order was reversed.

The results show a marked difference in the average distance of the mark made with the 2 types of example: F procedure, 9.4, centimeters, S procedure, 2.7 centimeters; N procedure, 4.1 centimeters. Of the 18 children, 16 showed greater distance under F than under S suggestion. There were, however, striking individual differences between the reactions of the children. Some totally disregarded the suggestions, others followed them exactly. A third group were erratic in their acceptance or rejection.

The sources of error in this test were the irregularity in outline of the dog, which made the measurement of distance somewhat inaccurate, and the fact that it was not always in the exact center of the page. These two difficulties were eliminated in the final form of the test, used in the major study.

EXPERIMENTAL METHODS

Subjects

The subjects used were drawn from four different sources, 31 from the Child Institute of the Johns Hopkins Psychology Department, 83 from the kindergarten and first grade of two private schools, and 22 from the nursery school of a recreation center. All came from distinctly superior homes except the last group which were from a poor district.

In all 136 children took the tests. The oldest was 7:5, the youngest 1:11 years old. Age is reckoned to the nearest month on the day the first test was given. The subjects were divided into two experimental groups, A and B, and a control group, C. Table 1 shows the age and sex distribution of the subjects completing the two tests.

Schedule of testing

Each child was tested six times with approximately a week between each test. In a few cases this was shortened to six days because of a change in schedule. Absences of the children caused by illness, vacations, and quarantines lengthened the period between tests to more than a week in some cases. Table 2 shows the number of cases in which this occurred. All of the testing took place between the hours of 9 and 11 in the morning.

The three types of procedure were given in a different order to the children in the three groups. No suggestion was used for all of the children in the first and last test periods. Group A was tested with fast or F

suggestion at the second and fourth test periods, and by the slow or S at the third and fifth. In group B this order was reversed. The control group, C, received no suggestion throughout.

TABLE 1

Age and sex distribution of subjects completing tests

The 3 year age group includes those from 2:7 to 3:6 inclusive

	AGE					AVERAGE	BOYS	GIRLS	TOTAL
	3 years	4 years	5 years	6 years	7 years				
Punching Test:									
Group A	1	10	9	13	7	5 years 4 months 29 days	19	21	40
Group B	2	10	12	17	6	5 years 3 months 23 days	24	17	41
Group C	1	4	12	3	0	4 years 10 months 24 days	13	7	20
Total	4	24	32	28	13		56	45	101
Marking Test:									
Group A	2	6	11	13	7	5 years 5 months 13 days	19	20	39
Group B	3	11	15	11	6	5 years 2 months 9 days	27	19	46
Group C	2	5	12	3	0	4 years 4 months 15 days	14	8	22
Total	7	22	38	27	13		64	43	107

TABLE 2

Time intervening between first and last test periods

5– indicates 5 or 5 and a fraction weeks

	5– WEEKS	6– WEEKS	7– WEEKS	8– WEEKS	9– WEEKS	TOTAL
Punching Test:						
Group A	25	11	3	1	0	40
Group B	20	14	6	1	0	41
Group C	4	6	5	4	1	20
Total	49	31	14	6	1	101
Marking Test:						
Group A	20	15	3	1	0	39
Group B	18	18	9	1	0	46
Group C	5	6	6	4	1	22
Total	43	39	18	6	1	107

Punching Test

The procedure in this test was identical with that of the preliminary punching, Form B. The punching form with 10 circles printed in a row was used (fig. 1) with the 3 types of instructions: fast, in which the experimenter demonstrated by punching the 10 holes in 5 seconds; slow, in which they were punched in 20 seconds; and no suggestion, where only two of the holes were punched. A slight variation in method was made for the C

group who were tested without suggestion throughout. After the first test period the experimenter did not punch any of the holes but merely gave the verbal instructions.

The children's behavior in the test situation was interesting. All of them seemed to enjoy this test. Several of those in the first grade remarked upon its being too easy and became rather bored by the sixth trial, but none refused to do what was desired. They were often impatient to start and would say, "I know how," trying to take the stylus before the experimenter had time to complete her demonstration. Sometimes as they watched they would make rhythmic motions in time with her movements, nodding the head or swaying the whole body a little.

There were several unavoidable sources of error in the procedure. One has been mentioned in the problem of the use of the right or left hand. In addition the method of holding the stylus and of punching varied greatly. Some children would punch lightly, making small holes, others very deeply, pushing the stylus completely through the pad to the table top. Another difficulty met with especially in the younger children was irregular order of punching. Finally, several of the children had the tendency to stop and talk during the test. If any of these disturbing elements entered in too marked a degree, timing became inaccurate and the test is classed as not completed. This took place in only 5 subjects above 3 years of age, but in practically all below that age.

Marking Test

The procedure used was identical with that in the preliminary marking test except that a picture of a house (fig. 3) was substituted for that of the dog, and the word "house" used in the instructions in the place of "doggie." On the whole this test did not interest the children as much as the punching. Several asked for a more difficult task. There was a compensating advantage in the simplicity of the reaction since younger children were able to do it successfully than could do the punching. There was one factor introducing error. In several cases a child would

FIG. 3. MARKING SHEET

not wait for the second instruction before making his second mark, thus only one visual suggestion was given instead of the usual two. The results show that this is not as significant as first appears, since the right and left hand marks were in general remarkably symmetrical in their distance from the house.

TREATMENT OF DATA

Group results, Punching Test

The number of seconds taken to punch the ten holes constitutes each

day's score in this test. Table 3 shows the mean scores for each group. Detailed tables giving individual results are in a dissertation on file in the library of the Johns Hopkins University. The influence of suggestion is clearly perceptible in the group averages. For example the scores of Group A fluctuate from 16 to 12 seconds in accordance with the type of suggestion. This difference is made clear by comparing the sum of the two average scores under F suggestion with the sum of the 2 under S suggestion, and also with the scores when no suggestion is given. The ence is 6 and 6.4 seconds respectively or 20 and 22 per cent of the N reaction.

The factor of practice effect is one which needs to be considered. If it existed to any large extent it would increase the difference between the F and S reactions in the B Group where the slower suggestion comes first, and decrease this difference in the A Group where the faster comes first. The average punching time in the six consecutive trials of the A and B Groups was as follows: 16.2 seconds, 14.3 seconds, 14.5 seconds, 13.7 seconds, 13.3 seconds, 13.2 seconds. The effect

TABLE 3

Mean scores of the three groups

	NUMBER OF CASES	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4	TRIAL 5	TRIAL 6	F	S	N	DIFFERENCE BETWEEN F AND S
Punching Test:											
Group A	40	16.3	12.3	16.3	12.8	14.8	13.9	25.1	31.1	30.2	6.0 ±.69
Group B	41	16.0	16.2	12.6	14.5	11.7	12.5	24.3	30.7	28.4	6.4 ±.84
Group C	20	16.9	16.2	15.5	14.3	14.9	16.1	30.5	30.4	32.0	.1
Marking Test:											
Group A	39	3.2	13.6	2.7	12.8	4.1	4.9	26.4	6.8	8.1	19.6 ±1.35
Group B	46	2.2	1.9	11.1	3.1	11.5	5.2	22.6	4.9	7.4	17.7 ±1.37
Group C	22	1.8	1.6	1.8	1.5	1.4	1.5	3.1	3.2	3.3	.1

last column of table 3 shows this difference and its probable error. As a check the results from Group C, where no suggestion was given, are treated as those in the A Group; that is, the first and sixth trials are classed under N, the second and fourth under F, and the third and fifth under S. This demonstrates clearly that the type of suggestion given had a definite effect upon the children's reactions. In the C Group the difference between the F and S scores is only one-tenth of a second, or .3 per cent of the N reaction, while in the A and B Groups the differ- of practice was small except in the first trial where the task was new to the children. This demonstrates the wisdom of giving a preliminary trial to accustom the children to the test situation, even though the reaction required of them may be very simple.

The mean time, of six trials, taken by each child to punch the 10 holes varied from 8 to 25 seconds. Age seemed to have some influence on this general speed of reaction, though not as great difference was found between the 4 and 7 year old reactions as between the F and S. Table 4 gives these

results. The smallness of the age groups permits only the generalization that there seems to be a tendency toward greater speed of reaction with increasing age.

Group results, Marking Test

The children's reactions in the Marking Test were scored by measuring in centimeters the horizontal distance from their mark to the side of the house. Variations in type of mark introduced some difficulties. These were eliminated by establishing the rule that the measurement should be made from the point where the child first touched the crayon to paper. In cases where this point was so near the top of the sheet that a horizontal line would strike the roof instead of the side of the house, measurement was made as thought the side extended vertically to the top of the paper.

Daily scores were obtained by adding the distances of the right and left hand marks. This obscures the factor of symmetry between the distances at the right and left sides of the picture. On the whole the children were remarkably consistent in the reactions on the two sides. There was less than 3 centimeters difference between the two in 93 per cent of the cases in the A and B Groups, and in 100 per cent in the C Group.

The influence of suggestion is even more marked than in the Punching Test. Table 3 shows the mean scores of the three groups. It is possible to pick out the trials where F suggestion was given by the large size of the score. The delayed influence of suggestion appears here quite clearly in the sixth score of the A and B Groups which is about twice as large as the first score although both were under no suggestion. In the C Group there was no possibility of delayed suggestion and the first and last scores are practically identical. The sum of the two F, S, and N reactions makes the effect of suggestion even clearer. This also appears in table 3. Here again the results from Group C are treated as those in Group A. The difference between the F and S scores in the C Group is 3 per cent of the N reaction, and in the A and B Groups 41 and 42 per cent respectively.

TABLE 4

Age differences in time scores of the punching test

Means of individual scores given in seconds

	AGE				
	3 years	4 years	5 years	6 years	7 years
Group A	19.1	17.6	14.7	12.1	12.7
Group B	14.2	16.1	13.4	13.2	12.2
Group C	23.1	16.6	15.0	13.4	

Suggestibility scores

From the four daily scores of each child under the F and S suggestion a suggestibility score was computed for

each test. In the Marking Test this consisted of the difference between the sum of the two scores under F suggestion and the sum of the two under S. So if a child drew his mark close to the house when the suggestion was close, and far from it when the suggestion was far, his suggestibility score would be high, denoting positive suggestion. If he paid no attention to the suggestion but marked in the same place throughout, the score would be zero denoting no suggestibility. And finally if he marked near when the suggestion was far, and far when it was near, the score would be a negative quantity, denoting negative suggestibility. There were few of this latter type.

In the Punching Test the simple difference between the scores under F and S suggestion was not an accurate measure of suggestibility because it did not take into account the factor of variations in the speed of punching from child to child. One who was slow in all his reactions would have a proportionally larger difference between those under F and S, and his suggestibility score would be weighted to that degree. The average speed varied from 8 to 25 seconds so this error would be quite large. To overcome the difficulty a ratio was used, since it is relative difference in speed under the two types of suggestion that counts, not absolute difference.

Therefore the suggestibility score in punching is the ratio between the sum of the two daily scores under slow sug-

TABLE 5

Distribution of suggestibility scores in the punching test

Score .60 includes values from .60 through .69

	SCORE																	
	.60	.70	.80	.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30
Group A	1	0	2	1	10	5	6	4	2	4	0	2	0	1	1	0	0	1
Group B	1	0	2	3	5	7	3	1	5	2	6	2	2	1	0	1	0	0
Group C	1	0	3	2	0	4	1	0	0	0	0	0	0	0	0	0	0	0
Groups A and B	2	0	4	4	15	12	9	5	7	6	6	4	2	2	1	1	0	1

TABLE 6

Distribution of suggestibility scores in the marking test

Score 4 includes values from 4 through 7.9

	SCORE										
	−4	0	4	8	12	16	20	24	28	32	36
Group A	2	5	2	4	2	2	6	4	4	4	4
Group B	2	11	3	4	3	4	0	2	6	6	5
Group C	0	15	0	0	0	0	0	0	0	0	0
Groups A and B	4	16	5	8	5	6	6	6	10	10	9

gestion and the sum of the two daily scores under fast suggestion. A score above one means positive suggestibility, below one negative suggestibility, and unity means that suggestion has no effect. In comparing the suggestibility scores of the two tests a zero score in Marking is equivalent to a unity score in Punching.

The average suggestibility scores of the 3 groups were as follows: Punching Test, Group A, 1.28 ±.04, Group B 1.33 ±.04, Group C 1.00; Marking Test, Group A 19.6 ±1.35, Group B 17.7 ±1.37, Group C 0.1. The difference in score between the experimental and control groups is quite marked and several times the size of the probable error. The distribution of suggestibility scores, shown in tables 5 and 6 makes this difference even more clear. We see that a large majority of the scores fall above that point denoting no suggestion. There are very few that show negative suggestibility. The distributions of the A and B Groups are quite similar throughout in contrast with the C Group where the scores are closely grouped around the point of no suggestion.

Combining the distributions of the A and B Groups gives an interesting contrast between the two tests (fig. 4). Both have a mode corresponding to the score denoting lack of either positive or negative suggestion. The Punching Test gives a skewed unimodal distribution, with more cases showing positive than negative suggestion. The Marking Test has a bimodal curve, one mode appearing at the point of no suggestibility and a second smaller one at high suggestibility. These two types of curve are similar to those which Estabrooks (9) attributed to emotional and non-emotional situations, and identified with Aveling and Hargreaves' (1) "Prestige and Non-prestige" tests. The U-type of curve supposedly appears when prestige or emotion are present. The factor of prestige certainly entered equally into both Punching and Mark-

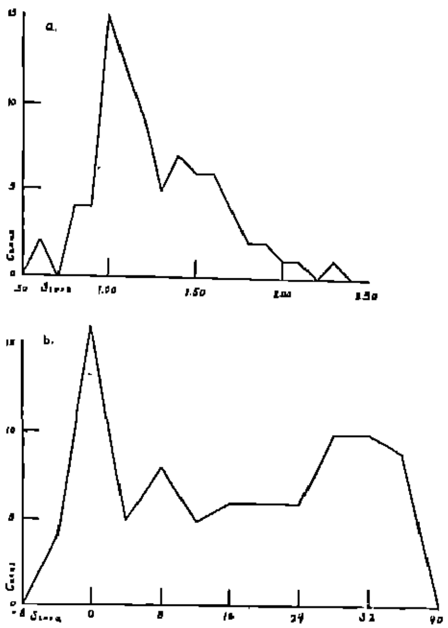

FIG. 4. DISTRIBUTION OF SUGGESTIBILITY SCORES

a, Punching Test; *b*, Marking Test

ing, for the same experimenter demonstrated in both. Nor does emotion appear to be significant. If anything, greater emotion would appear in the Punching Test, which was a more novel situation and a more difficult task, than in the Marking Test, yet the latter has the supposedly emotional type of curve.

Two possible explanations of this difference in the distribution of scores are the relative obviousness of the suggestions in the two tests, and the relative ease of following them. Perception of distance is probably a more simple reaction than perception of speed, making the Punching Test suggestion more difficult to follow. In addition the suggestion in the Marking Test was more obvious because it was before the child while he was reacting, while in the Punching Test it was already merely a memory. The second factor accounting for higher suggestibility in the Marking Test is the ease of following the suggestion. Any child could make his mark near or far from the house, but not any child could follow the fast speed of punching. Especially were the younger ones thus handicapped.

Individual reaction curves

An analysis of the curves representing the six consecutive daily reactions of each child reveals many interesting variations. Figures 5 and 6 show typical curves in relation to the suggestions which were given. Since the type of measurement in the two tests was different, the curves resulting cannot be compared directly, and a separate analysis of each is necessary.

Punching Test. It was difficult to classify the individual reaction curves of the Punching Test into types owing to the large number of variations present. In some cases the child's reactions followed those of the experimenter fairly closely, for example figure 5 (*b*), representing the reactions of a child in Group A, is of the same form as figure 5 (*a*), representing the experimenter's reactions in giving the suggestions to that group. Dotted lines connect those points representing reactions where no suggestion was given. Figures 5 (*c*) and (*d*) illustrate the experimenter's and a child's reactions in Group B. Both of these children were highly susceptible to suggestion

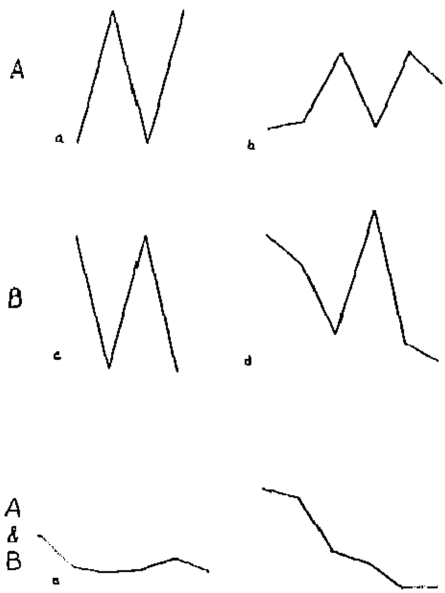

FIG. 5. INDIVIDUAL REACTION CURVES, PUNCHING TEST

a, suggestions given to Group A; *b*, fluctuating curve of Group A; *c*, suggestions given to Group B; *d*, fluctuating curve of Group B; *e*, level curve; *f*, practice curve

and received a high suggestibility score. There are cases, however, of children receiving a high score whose curve was not as typical as these.

In contrast to those curves which demonstrate the effect of suggestion we find some which are fairly level, figure 5 (*e*), and others which are in the form of a typical practice curve, figure

5 (*f*). These two types represent low suggestibility. Each type is not distinct from the others but grades into them by imperceptible degrees. It is necessary to make some arbitrary definition of the limits of each, as follows:

1. Fluctuating Type, more than six seconds difference between the highest and lowest records (fig. 5(*b*) and 5 (*d*)).
2. Level Type, not more than six seconds difference between the highest and lowest records (fig. 5 (*e*)).
3. Practice Type, more than six seconds drop from the first to the last record, and not more than a two second rise at any one point (fig. 5 (*f*)).

Group B is easily explicable, since the order of giving the suggestions, slow then fast, would facilitate the practice effect more than the fast-slow order given to the A Group.

Marking Test. It is possible to distinguish types much more definitely in the Marking Test than in Punching. The following are rather sharply differentiated from each other:

1. "M" Type, in which the reactions follow the suggestions almost exactly, forming an M-shaped curve. Figure 6 (*b*) represents this type of reaction in the A Group following the suggested reactions shown in figure 6 (*a*).

TABLE 7

Distribution of curve types in the punching test

	GROUP A		GROUP B		GROUP C	
Fluctuating Type:						
Score above 1.50	9		11		0	
Score 1.20 to 1.50	10		8		1	
Score below 1.20	7		6		0	
Total		26		25		10
Level Type		12		11		7
Practice Type		2		5		3

The frequency of these types is given in table 7. The distribution in the A and B groups is similar. About two-thirds of the curves are of the fluctuating type. The rest are fairly level. In the C group where no suggestion was given the proportion of irregular curves is lower, being exactly one-half. But even here there were individuals who were as variable in their reactions as some who were given suggestions. In all three groups the number of practice curves is small, showing that the reaction was one so simple that not much improvement occurred. The larger number of curves of this type in

Figures 6 (*c*) and 6 (*d*) represent the same for Group B.

2. "V" Type, in which the F suggestion is followed only once, forming a level line with only one pronounced peak, like an inverted V. Figure 6 (*e*) is an example of this type of curve in the B Group. Similar curves occurred in the A Group, with the peak at other points.
3. Delayed Type, in which the F suggestion is effective on trials where it is not given. An example of this curve in the B Group is given in figure 6 (*g*). It occurred also in the A Group.
4. Level Type, where there is no evidence of the effect of suggestion. This is in sharp contrast to all of the other types. Figure 6 (*f*) is an example.

It occurred in all three groups and is the only type appearing in Group C where no suggestions were given.

5. Irregular, fluctuating and unclassifiable. Only 2 children exhibited this type.

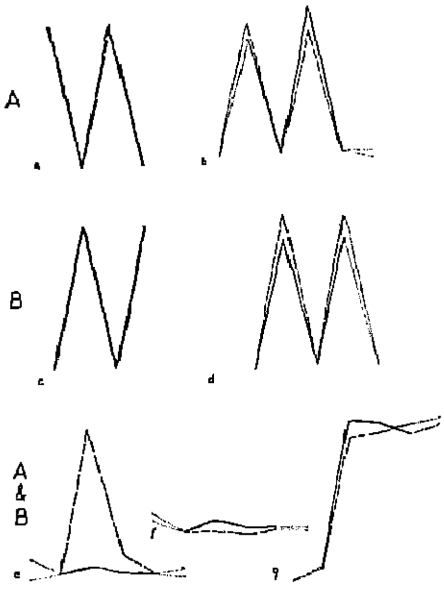

FIG. 6. INDIVIDUAL REACTION CURVES, MARKING TEST

a, suggestions given to Group A; *b*, M Type curve of Group A; *c*, suggestions given to Group B; *d*, M Type curve of Group B; *e*, V Type curve; *f*, level curve; *g*, delayed curve. Unbroken line denotes right side reaction, broken line, left side reactions.

The distribution of each type in the three groups is shown in table 8. Right and left side reactions are both considered and their sum given. Here the contrast of the C Group with the A and B is even more marked than in Punching. Over a third of the children in the first two groups followed the suggestions very closely, and about three-fourths were influenced by them to some extent. The fact, however, that several curves of the level type were found in both the A and B groups indicates that there were some children on whom the suggestion seemed to have absolutely no effect.

The factor of symmetry is illustrated clearly by figure 6. A majority of the individual curves were as those in figure 6 (*b*), (*d*), (*f*), and (*g*), where the right and left side reactions were placed at symmetrical distances from the picture of the house, and are plotted as practically identical curves. There were some cases, however, where the mark on one side was placed near, the other far. Figure 6 (*e*) illustrates one of this type.

The relation which the suggested reactions bear to the children's initial reactions forms an interesting contrast in the 2 tests. In Punching the S suggestion was sometimes faster and sometimes slower than the child's own reaction when no suggestion was given. If it were slower it often produced an inhibitory effect, slowing down the child's speed, as in figure 5 (*b*). If it were faster it would speed up the reaction, as occurred to a slight extent in figure 5 (*d*). The F suggestion was in all cases faster than the child's initial reaction and so produced speeding up when it was effective.

In the Marking Test on the other hand, the F suggestion was the only one which had any effect in changing the children's reaction. In practically all cases the S suggestion coincided very closely with the child's own reaction when no suggestion was given. Figure 6 illustrates this clearly. All of the initial reactions in the children's curves are near the S distance. This

fact seems to be responsible for the larger number of cases of level curves in the B than in the A Group. In the former the S suggestion was given first. Being similar to the child's own reaction, this suggestion reinforced it and made him impervious to the later F suggestions. In the A Group the F came first and not having so much resistance to overcome was more successful in producing acceptance, so the number of M type curves is larger than in Group B.

The difference between the F and S suggestions was more definite in Marking than in Punching. This may account for the higher suggestibility in Marking and for the fact that the curve types are more distinct here.

TABLE 8

Distribution of curve types in the marking test

	GROUP A	GROUP B	GROUP C
M Type	35	28	0
V Type	17	15	0
Delayed Type	10	17	0
Level Type	14	30	40
Irregular Type	2	2	0

Consistency

The problem of an individual's consistency in his acceptance of suggestion is one which has received much consideration. In general the results of previous experimentation indicate that suggestibility is not a persistent trait of personality, but is related to the specific situation. The findings of this study uphold these conclusions.

There were several methods of studying how consistent the children were in their suggestibility. One method was that ordinarily used in measuring reliability. The tests were divided in two parts and the halves correlated. In Marking this was done by finding the difference between the daily score under F and S suggestion in the second and third daily periods, and the difference in the fourth and fifth. These two scores were then correlated. The coefficients obtained were not high but of some significance, indicating that a child who followed the suggestions in the first part of the experiment was likely to do so in the latter half. They were for the A group .40 ±.08,* and for the B group .55 ±.07.

Fourteen of the children had been given the Marking Test before in practically identical form, Marking Dog. They formed a group whose consistency could be measured in another way. This was done by correlating the suggestibility scores on the two tests. The coefficient here was again positive, .35, ±.16, but the smallness of the group made the probable error so large that it cannot be considered significant.

Consistency of reaction on the Punching Test was studied in the same way as Marking. A ratio between the first two F and S reactions was com-

* All correlations were computed by the rank order method using Pearsons "Rho" Formula.

puted, similar to the suggestibility score for the whole test, and this was correlated with a ratio obtained from the last two F and S scores. Here the coefficients obtained, though positive, were very low and cannot be considered significant. They were in the A Group .10 ±.29 in the B Group .30 ±.17. From this we infer that the children more suggestible in one part of the Punching Test are not especially likely to be so in the other.

A final method of measuring consistency of response to suggestive stimuli consisted in correlating the scores of the two tests, Punching and Marking. Here again the coefficient was low with a large probable error, .12 ±.11. We must therefore conclude that suggestibility as here measured is not a persistent trait but one which varies greatly from situation to situation and from time to time in the same situation.

Age and sex differences

The influence of age on suggestibility score is different in the two tests. In punching there is a positive correlation represented by the coefficient .47 ±.09. Th's relationship is shown in table 9 which gives the average score for the various age groups. The C group indicates that where no suggestion is present the score does not vary with age. We may therefore conclude that in this test the older children are more suggestible. This is not true in the Marking Test. The coefficient of correlation between age and suggestibility score is not significant, being .25 ±.10. The average scores for the different ages, shown in table 9, indicates this slight tendency towards decreasing score with decreasing age.

TABLE 9

Age differences in mean suggestibility scores

	AGE				
	3 years	4 years	5 years	6 years	7 years
Punching Test:					
Group A	1.02	1.24	1.22	1.33	1.30
Group B	1.10	1.05	1.30	1.53	1.59
Group C	.01	1.03	1.01	.07	
Marking Test:					
Group A	12.0	17.5	14.1	22.8	26.4
Group B	0.4	17.0	17.2	20.2	17.0
Group C	−3.1	.4	.2	−.3	

The factor of relative difficulty of the two tests may again be used in explanation of this difference between them. The Marking Test would indicate that four year old children are as susceptible to suggestion as those of six and seven, when they can comprehend it and are able to carry it out. In the Punching Test their lack of manual dexterity and perhaps the fact that they do not easily perceive the sugges-

tion, speed of movement, makes them less suggestible than those somewhat older.

No significant sex differences were found. In the Punching Test the difference in score between the boys and girls was in Group A .13 ±.07, in Group B .08 ±.07, the girls being slightly more suggestible. In the Marking Test the boys were more suggestible in Group A by a difference of .9 and the girls in Group B by a difference of 3.4.

SUMMARY

Varying types of experimental situations were used in an endeavor to select some which would give a measure of a child's response to suggestive stimuli. Two coördination tests given with positive and negative instructions gave indications that the negative instructions produced no perceptible effect. Two tests involving drawing were not continued because they measured only acceptance or non-acceptance of suggestion and not the extent of each. A test in which gross bodily movements were involved proved unsatisfactory because of the length of time required for response and the possibility of distraction of the child's attention by other factors.

Two tests were finally adopted for a more extensive study in which visual stimuli acted as suggestions influencing simple hand movements. Measurements of the reactions of 101 children from 3 to 7 years of age under two opposing types of suggestion showed a definite effect which a control group of 35 children, who were given no suggestions, did not exhibit.

Several conclusions regarding suggestibility may be drawn from the results of this study.

1. Most children are suggestible to a certain degree in one situation or another, although a few appear to be uninfluenced by visual suggestion of the type used. In some suggestion has a delayed effect. Negative suggestibility is rare.

2. Suggestions of two opposing types are accepted successively when a time interval occurs between their presentation. Suggestions which are similar to a child's own method of reaction reinforce his tendency and make opposing suggestions less effective.

3. The extent to which suggestion is followed depends on the obviousness of the suggestion and the ease of performing the movements which it involves.

4. Children are not consistent in their acceptance or rejection of suggestion. In repetition of identical situations there is some probability that they will react in the same way, but this is not true if a time interval of more than a few weeks intervenes. Individual suggestibility in one type of situation seems to bear no relation to that in another.

5. Suggestibility increases slightly with age in the age range here considered. No sex differences are apparent.

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The Anatomical Features of Epiphysial Union[1]

T. WINGATE TODD

MODERN INVESTIGATION OF EPIPHYSIAL UNION

SEVEN years ago when we first began to have doubts concerning the reliability of the time tables of epiphysial union contained in anatomical texts, I requested Stevenson to make a careful study of the various standard descriptions with a view to tracing their origin. A bare summary of his results is given in a paper published by him at that time. Internal evidence points to all modern textbook accounts having been derived directly or indirectly from the account by Henle in the middle of last century (6). Apparently Henle had some adolescent skeletons upon which to base his description. Since then minor changes have been introduced into Henle's account though most of the modifications have been made upon what, in the light of our evidence, is clearly untrustworthy observation. Dwight alone had material which permitted him to feel at liberty to make quite bold and definite alterations in Henle's schedule. This induced me to attempt a survey of all skeletons of known individuals and exact age from the bodies of children and adolescents housed in the anatomical laboratories of the United States, Canada and Great Britain. I hoped in this manner to amplify the observations made on our own collection which then numbered over one hundred and now exceeds two hundred. The answers to my letters were most unsatisfactory and disclosed, in the three countries, only 5 skeletons for which the age could be given with any close degree of approximation. This extraordinary state of affairs should be borne in mind in considering the evidence which we present from the comparatively rich collection in Cleveland. And it should be particularly remembered in weighing the adverse criticism of others who have reproached us from time to time for the temerity with which we have ventured to question current teaching.

The object of this paper is to set forth the facts of epiphysial union as seen on the actual bones and on roentgenograms of them. Our observations have a definiteness and assurance which can only arise from the advantage of examining in detail the very bones roentgenographed. However voluminous the data gathered from roentgenograms not so con-

[1] This is the second of a series of studies on Comparative Youth from the Hamann Museum, Laboratory of Anatomy, Western Reserve University, Cleveland, Ohio, prepared for the White House Conference.

trolled, the total result is almost worthless because the investigators have had no opportunity of testing their interpretations of the roentgenograms. In making such a statement the reader who may be amazed at its drastic character, should remember that I refer to the large or deeply placed diaphyso-epiphysial sites only. In elbow, wrist and ankle, but still more in shoulder, knee and hip the overlapping roentgenographic shadows and the obscuration of outline by the overlying soft tissues render interpretation of roentgenograms most hazardous without a course of careful training in comparison of roentgenogram with naked bones. Most of those who have felt impelled to challenge the observations published by Stevenson under my direction have relied upon their ability to read a roentgenogram without this controlling dissection (7, 8, 9, 10, 17). One author has utilized mammalian material which he has indeed dissected (1) but has later gracefully acknowledged (2) after consultation to have been anomolous in that it shows what I have described as lapsed union (13). Another (4) has based his objection on very inadequate observation of a few mammalian skeletons. His findings are of no account when set beside the comprehensive survey of over a thousand mammalian skeletons which I have investigated for this purpose.

Stevenson's investigation was confined to the long limb bones excluding hand and foot, to the scapulae, ribs and ossa innominata (11). Later D'Errico extended the inquiry, also under my direction, to the clavicles (14). These researches are but a small part of the vigorous and comprehensive survey which I have personally undertaken of all epiphyses of the mammalia including man and have prosecuted continuously for the last eight years as a part of the investigation of age changes in skeletons. The survey completed to date covers more than three thousand human skeletons of which eighteen hundred are those of known individuals whose age is ascertained. These are in the collection at Western Reserve University. Twelve hundred are drawn from archeological investigations in New Mexico and Arizona. These skeletons are now housed in the American Museum of Natural History and in the Peabody Museum of Harvard University. For the opportunity to examine them I am indebted to Doctor Clark Wissler, Doctor E. A. Hooton and Doctor A. V. Kidder. The remainder are of miscellaneous origin both in place and time. They include the Scarborough series and others now in the collection at the Royal College of Surgeons which were kindly placed at my disposal by Sir Arthur Keith.

The mammalian skeletons numbering upwards of one thousand including one hundred and fifty anthropoids, comprise the collections in the Hamann Museum of Western Reserve University gathered together by myself for investigations on growth, in the Royal College of Surgeons, the American Museum of Natural History, the National Museum at Washington and the Field Museum in Chicago.

Publication of our findings has been purposely delayed, in spite of incitement to reply to adverse criticism, for two reasons. First the more deeply

we progressed into the subject the more complex it grew and the greater the number of problems which arose out of it. Until we were able to make an adequate comparison of skeletal maturation in man with that of other mammals I felt a lack of fundamental knowledge. This has now been obtained and an initial statement of our findings has gone to press under the title Comparative Youth (15). Secondly I desired, before publication, to put our observations to the intensely pragmatic test of clinical application. Having now had the opportunity of thoroughly investigating skeletal maturation on over one thousand living children whom we have examined roentgenographically at intervals of several months up to two years, and on the latest of which we have also had the confirming evidence of psychological tests, I feel free to set forth our results in detail with confidence.

The reason why Stevenson found such striking uniformity in order of epiphysial union is that this order is a feature of mammalian development in general. There are exceptions, ordinal and generic divergences, but fundamentally and essentially the order-pattern is mammalian in extent. The reason why Stevenson found so close a time-relationship is that the period eighteen to twenty-two human years is that of most stable and uniform human maturation in both sexes and in both white and negro stocks. The reason why our investigations of epiphysial union during these early adult years bear results differing fundamentally from those of other workers is that we alone have had the opportunity of checking our roentgenographic observations upon the actual bones roentgenographed and that we alone have had at our disposal criteria establishing the normal or pathological character of the diaphyseo-epiphysial site.

In this paper I propose to set forth the results of our observations upon actual epiphysial union and its exhibition in roentgenograms.

THE PROGRESS OF EPIPHYSIAL MATURATION AND UNION

It has already been stated that previous to our investigations Dwight (3) is the only modern anatomist who has had the necessary material upon which to base an original study of epiphysial union. I have been unable to unearth the material upon which these investigations were made but our experience confirms Dwight's conclusions on limb bones, barring hand and foot, in practically every respect. For an adequate understanding, however, of the process of epiphysial union it is necessary to make a more detailed examination.

The sites where the successive stages can be most easily followed and, indeed, can be identified on the roentgenogram if the actual bones are not available, are the lower end of radius and distal extremity of the humerus. In the description which follows the reader will understand that, though adequate handling of the subject requires a knowledge extending beyond these two areas it is on these that the reader, with material or roentgenograms at his disposal, will most conveniently be able to follow our description.

An epiphysis is often loosely thought of as a bony cap to the shaft. It is not. It is a cartilaginous cap which eventually ossifies completely, in part, or not at all. Whether the epiphysis ossifies or not, the adjacent area of the shaft goes through identical stages of progress. If the epiphysis does ossify it also goes through the same stages. Lower epiphysis of radius and capitulum of humerus do ossify completely. It is only in the latest stages when overlapping shadows may confuse their roentgenographic picture. They may therefore be relied upon, almost to the conclusion of union, to give confirmation of our description. The approximate age relationships are given for males. Reference will rarely be made to females in order to avoid confusion and excessive length of discussion.

There first appears that early stage when the ossification in the epiphysis is nothing more than a nodule of approximately spherical form and the adjacent area of the bony shaft is similarly devoid of characteristic shape.

This is followed by progressive ossification of the epiphysis which in its bony outline comes to reproduce more and more accurately the outline of the growing cartilaginous epiphysis. At the same time ossification continues in the shaft. As a result the adjacent surfaces of epiphysis and shaft are reproduced in reciprocal outline of cancellous bone. There is no condensation of the surface even into the thinnest layer of compacta. When the structures are macerated at this stage the cancellous character of the surfaces is plainly apparent to the naked eye. They are friable and easily damaged.

The considerable interval between shaft and epiphysial surface characteristic of this stage is maintained until shortly before union takes place.

The second stage is a change in the bone texture adjacent to the delimiting surface both on shaft and epiphysis. This is apparent on the roentgenogram as a hazy ribbon involving the bony surface and extending deeply from it into the bony substance to a depth, on the shaft side, of approximately three millimeters, less on the epiphysial side. Exactly what happens to produce this appearance will doubtless eventually be determined by histological research. We do know that an oedema produces a like result and the area can be picked out and distinguished from the rest of the bony by differential staining by toluidin. Coincident with this appearance which occurs in the knee at approximately seven years there is a temporary pause in growth. In the knee this stage lasts six to twelve months. A similar appearance may supervene during and shortly after one of the exanthemata or other toxic condition. It remains a variable time after such origination as fine white scar.

The third stage is a progressive clearing of this haziness. As the bony outlines again become clear they possess a thin coating of more condensed osseous tissue which is identifiable on the roentgenogram as a fine delimiting line of bone at the adjacent surfaces of shaft and epiphysis. The duration of this stage varies and we do not yet know its time limits for the several sites.

Following upon the definition of the bony surface the fourth stage supervenes. This is the stage of billowing which is of considerable duration. I have described it in detail for the symphysis pubis (12) where it lasts almost throughout the second decade. It is first seen in the roentgenogram of the lower end of the radius at about seven years and a half, on the capitular surface of humeral shaft at about five years and on the olecranon six months later. A similar billowing can be seen on the surface of the bone of the developing femoral condyles and trochlear surface between five and six years. In this location I have known it sometimes mistaken for commencing tuberculosis.

The billowing is most regular and easily seen roentgenographically at the symphysis pubis but once the reader has found it there he will readily identify it elsewhere. I have given a full description of its appearance on the pubic bone in my earlier studies already mentioned and in a recent record of our roentgenographic observations (16).

The fifth stage is the stabilization of parallelism in diaphysial and epiphysial bony outline. It occurs in the male diaphysoepiphysial area for the humeral capitulum at about eleven and a half years though its occurrence may be as much as two years earlier in the female. At this site then the lateral roentgenogram shows a definite parallelism in the clear white billowy outlines of adjacent surfaces on shaft and epiphysis.

Shortly after Stevenson's observations had been published Hellman got the opportunity to study epiphysial union in the hand. Stage V as just described corresponds to Hellman's stage A (5).

Our stage VI, which corresponds to Hellman's stage B, supervenes at a date varying with the site but always later than the appearance of stage V. It is characterised by a narrowing of the gap between the parallel lines of shaft and epiphysial surfaces. At the capitulum it occurs at about thirteen years in the male, about a year earlier in the female. The definite white outline of surface is retained and ossification is completed characteristically into all remaining crannies of the outline. This final extension of ossification may fail as, for example, on the dorsal surface of the olecranon or just below the tibial tubercle but such imperfections are of no real significance. The cartilaginous pocket may be transformed into bone later

In the following stage, No. VII, corresponding to Hellman's stage C, there is a definite breaking up of adjacent outlines on the roentgenogram with patchy loss of the delimiting white line and extensions of bone across the intervening gap between shaft and epiphysis. This is the stage of commencing union. On actual dissection one finds that union always begins in the deeper parts of the diaphyso-epiphysial areas and extends erratically to the outer surface of the bone. Hence, so long as, to the naked eye, there is a gap, however narrow or restricted in extent, union has not been perfected. When the macerated or dissected bone no longer shows surface discontinuity one may be sure that union is completed.

In large diaphyso-epiphysial sites,

like the knee and femoral trochanters where there is much interdigitation of shaft and epiphysis, or in sites of extensive overlap like the upper ends of humerus and femur, the confusing medley of shadows on the roentgenogram actually obscures the precise relationship of shaft and epiphysis. The depth of soft tissues in all these areas adds to the difficulty of determination. For knee and shoulder stereoscopic roentgenograms are of some help though even with their aid judgment may be quite fallacious unless the investigator has trained himself very carefully by control observations on the bones by dissection and maceration after roentgenography. The record of the observations itself carries intrinsic evidence of its reliability or its worthlessness.

The reason for Hellman's conclusion that sometimes, in the phalanges, his stage B or C or both may be omitted is this very overlap of shadows. There is no doubt however that, in small areas like the phalangeal sites, Hellman's stages B, C, D may follow each other quite rapidly. Our corresponding stages VI, VII, VIII go through their gamut with astonishing speed at the outer end of the clavicle. At this site their sequence is so rapid and follows so fast upon ossification in the epiphysial cartilage that a lateral epiphysis to the clavicle finds no place in current descriptions of the skeleton. This was shown in great detail by D'Errico and myself (14).

Stage VIII, Hellman's stage D, is the early stage of complete epiphysial union. To the naked eye the diaphyso-epiphysial line of union shows on the outer surface of the bone as a thin red line. On the roentgenogram it is identified by a thicker single white line in place of the patchy irregularity with isolated areas of double fine lines paralleling each other on or between the patchy areas. On ankle, elbow and wrist it can be distinguished with difficulty from stage VII and I prefer myself to make no final judgment in most roentgenograms where stages VII to IX are in question. In knee, hip and shoulder it is distinguished with even greater difficulty and one may be quite uncertain of any stage between VI and IX inclusive.

The white line of the roentgenogram, characteristic of stage VIII, persists as a fine scar for some months. It may remain throughout life as it often does in the upper tibia, or it may disappear after about six months as it almost always does in lower ulna and, somewhat less often, in lower radius. We have defined this stage as recent union.

Stage IX, Hellman's stage E, is that of perfected union with continuity of the osseous trabeculae from shaft to epiphysis. When this stage supervenes all trace of epiphysial differentiation is lost.

THE AGE-ORDER OF EPIPHYSIAL UNION

Before closing this article we shall set forth in tabular form the age-order of epiphysial union as it occurs in human beings of both sexes and in sound condition (table 1). It must be remembered that all dates are subject to minor modification though the mass of our observations is already so huge that I doubt if much alteration will be necessary. There is an individual variation of which Hellman calculated the standard deviation as

three months, thus providing a normal limit of nine months on each side of the mean date. This accords with our observations. Further, in the absence of a birth certificate or at least the exact date of birth, a given age may refer to any date during the eighteen months which intervene between the birthday next above and half way towards the birthday next below. Our experience is that children of good physical grade usually present epiphysial stages in the upper nine months. We do not regard a child as retarded unless his skeletal maturation falls beyond the limit of the lower nine months.

IRREGULARITIES OF SKELETAL MATURATION

We do occasionally find children exhibiting a general acceleration of skeletal maturation and, far more rarely we find local accelerations. There is some correlation between stature and skeletal maturation of the knee. There is a rare local acceleration observed in hand only.

Far more often retardation is exhibited in skeletal maturation. It takes three forms.

1. General retardation or repression.
2. Local inhibition or lapsed union.
3. Temporary repression with irregular recovery.

In rare instances of pronounced pathological character we meet with total inhibition or general lapsed union. In such patients the age at which inhibition occurred can be definitely ascertained by a study of the roentgenograms.

This is not the place for a description of irregularities: they must be dealt with fully in later communications. They do however suggest that the entire pattern of skeletal maturation is under definite control and that deviations from the schedule of table 1, definitely identifiable, may be due to disorganization of, or interference, however slight, with this control.

TABLE 1

Age order of epiphysial union in man, partial list: identifiable roentgenographically

SKELETAL SITE	USUAL LIMITS OF UNION	
	Male	Female
	years	*years*
Humerus distal	14.0–15.0	12.5–13.5
Calcaneus	14.5–15.5	13.0–14.0
Foot 2nd and 3rd phal.	14.0–15.0	12.5–13.5
Foot 1st phal.	14.5–15.5	13.0–14.0
Ulna proximal	14.5–15.5	12.5–13.5
Hand 3rd phal.	14.5–15.5	13.0–14.0
Radius head	14.5–15.5	12.5–13.5
Humerus med. ep.	15.0–16.0	13.5–14.5
Os innom primary elements	15.0–16.0	13.0–14.0
Hand 1st phal.	15.0–16.0	14.0–15.0
Hand 2nd phal.	15.0–16.0	14.5–15.5
Metatarsals	15.0–16.0	14.0–15.0
Metacarpals	15.5–16.5	15.0–16.0
Tib. fib. distal*	15.5–16.5	14.5–15.5
Femoral head	17.0–18.0	17.0–18.0
Trochanters	17.0–18.0	17.0–18.0
Isch. tuber	17.0–18.0	17.0–18.0
Tib. fib. prox.	17.5–18.5	17.5–18.5
Femur dist	17.5–18.5	17.5–18.5
Radius, ulna dist.	18.0–19.0	18.0–19.0
Acromion	18.0–19.0	18.0–19.0
Clavicle lateral	19.0–20.0	19.0–20.0
Humerus prox.	19.5–20.5	19.5–20.5
Scapula lower angle	20.0–21.0	20.0–21.0
Scapula vert. border	20.0–21.0	20.0–21.0
Iliac crest	20.0–21.0	20.0–21.0
Clavicle sternal end	25.0–28.0	25.0–28.0

The complete list of epiphysial fusions will be given in a later communication. Many can be identified upon the skeleton only.

* May be revised.

SUMMARY

1. The general review of observations here recorded is part of our investigation of skeletal maturation and age changes. It has been carried out on over 3000 human skeletons of which 1800 were from known individuals of ascertained age. The investigations on skeletal maturation in childhood and youth cover 200 of the known skeletons. They also include over 1000 mammalian skeletons and a roentgenographic study of over 1000 children.

2. The progress of epiphysial maturation and union can readily be subdivided into nine stages.

The first extends to the period when diaphysial and epiphysial bone approximate each other but as yet show no intimate relation, the adjacent surfaces being ill-defined and composed of cancellous tissue.

The second is the stage of obscuration of the adjacent bony surfaces by their transformation into thick hazy zones.

The third stage shows clearing of the haze with appearance of a fine delimiting surface of more condensed tissue shown on the roentgenogram as a fine white line.

The fourth stage exhibits billowing of adjacent surfaces.

In the fifth the adjacent surfaces show reciprocal outlines which are parallel to each other.

In the sixth the gap between adjacent surfaces is narrowed.

The seventh is the stage of commencing union when the fine white billowed outlines break up.

In the eighth stage union is complete though recent and appears on the naked bone as a fine red line.

The ninth stage is that of perfected union with continuity of trabeculae from shaft to epiphysis.

3. The age order of union is perfectly definite in sound healthy human beings and a partial list of epiphysial unions with their dates is given. Those selected are of greatest service in checking maturation in relation to age.

4. The problem of irregularities in date of union is briefly reviewed but complete presentation of this subject is deferred for later consideration.

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The Learning of Abstract Concepts of Size[1]

J. Allan Hicks and Florence D. Stewart

In this experiment children two to five years of age were tested on their ability to learn to select the middle-size of 3 boxes. Six boxes varying proportionately in size were used to make up 4 series of 3 boxes each. Each series was presented in such order that after a child had learned to select the middle-size box in one group he was shown a new combination from which the "largest" box of the previous series had been dropped and a new "smallest" box added. This procedure made it possible to study the ability of children to apply the concept of size. If a child continued to select a box after it had become the largest rather than the middle-size box in a new series it indicated that he was selecting a particular box independent of its relation to the other 2 boxes. On the other hand, if he selected the middle-size box in a new series and ignored the box which he had been selecting in the former series, it indicated he was utilizing the concept of "middle-sizeness" independently of a particular box.

Forty children were studied—10 two-year-olds, 10 three-year-olds, 10 four-year-olds and 10 five-year-olds. Twenty children were attending the nursery school section of the Washington Child Research Center and 20 the pre-kindergarten and kindergarten classes of the John Quincy Adams School of the public school system of Washington, D. C. All the children are from homes in one of the better residential districts of Washington in which the cultural advantages are above average.

DESCRIPTION OF TEST

The 6 boxes used in this experiment were cubes open on one side. They varied proportionately in size from the largest box, with sides 14 centimeters long, to the smallest box with sides 4 centimeters long (fig. 1). All of the boxes were covered with red paper and were identical except in size.

A small toy was always placed under the middle-size box in order to help motivate its selection and to identify the correct response to the child. This procedure also served to make the experiment an interesting "game" for the child.

For clearness in discussion the boxes are indicated according to size by numbers ranging from 1 to 6, the largest box being number 1 and the smallest number 6. They were pre-

[1] This study was made at the Washington Child Research Center.

sented to each child in 4 series (fig. 1) of 3 boxes each in the following order:

POSITION	SERIES 1			SERIES 2			SERIES 3			SERIES 4		
a...	**2**	1	3	2	4	**3**	3	**4**	5	**5**	6	4
b...	1	3	**2**	4	**3**	2	**4**	5	3	4	**5**	6
c...	3	**2**	1	**3**	2	4	5	3	**4**	6	4	**5**

The number to the left in each of the above positions represents the box which was on the child's right as he faced the table. The boldfaced number in each case was the middle-size box in the particular series in which it was presented. By varying the position of the boxes during each series the factor of position as a possible basis of learning was eliminated. During a single practice period the 3 positions of a series were repeated 5 times in the order given. Thus 15 trials or choices were made by a child *in the course of each practice* period.

Each series was presented until the child made a perfect record on the 15 trials constituting a practice period. The next series was presented at the following practice period. If at the end of the sixth practice period or *after 90 trials* on the first series the child was not getting more than one-third of the responses correct he was deemed unable to learn to discriminate among the boxes and training was discontinued. The interval between practice periods was never less than one day nor more than three. Any subjects who were absent more than three consecutive days and could not be tested in their homes, were dropped from the experiment.

While arranging the boxes in position on the table approximately three inches apart the examiner concealed them from the child's view with a screen.

For the first trial on series 1 the boxes were presented to the child in position (a) in the following manner:

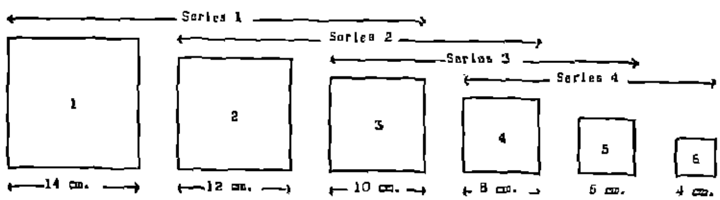

FIG. 1. SERIES OF BOXES IN SIZE RELATIONSHIP TEST

Pronouncing middle-size as nearly as possible as a unit with equal emphasis on both parts, the examiner said: "Now we are going to play a new game. Here is a middle-size box (pointing), a big box (pointing) and a tiny box (pointing). There is a toy under the middle-size box but there is nothing under the big box or the tiny box (lifting each box to demonstrate). Remember, the toy is always under the middle-size box."

The examiner placed the screen before the boxes and rearranged them in order 1 3 2 (position (b) in series 1). "Here is the big box (pointing), the tiny box (pointing) and the middle-

size box (pointing). And remember, the toy is always under the middle-size box." (Pause.) If the child indicated the wrong box, the examiner said: "No, that is the ———— box. The toy is always under the middle-size box (raising box)." If the correct box was indicated the examiner said, "Yes, the toy is always under the middle-size box."

"Now let us do it together once more before you do it alone." The boxes were arranged behind the screen in order 3 2 1 (position (c) in series 1). Pointing to the smallest box, the examiner said, "Here is—(pausing for response)." If the child did not respond immediately, the examiner completed the sentence, "—the tiny box." The same procedure was followed with the other boxes, the examiner pausing each time to give the child an opportunity to identify the box indicated. The examiner then continued: "Remember, the toy is always under the middle-size box. All right, find the toy for me." The subject was given time to indicate the box and the examiner commented upon his choice: "That is right" or, "No, that is the ————box, the toy is always under the middle-size box," (raising the middle-size box).

Following this demonstration the examiner began the test proper. The boxes were presented in position (a) of series 1 (2 1 3) with the instructions, "Now I want you to do it all by yourself and find the toy the very first time you try. Are you all ready? Remember, the toy is always under the middle-size box." After the child had made his choice, the examiner said: "That is right" or, "No, it's always under the middle-size box" (raising the middle-size box).

After rearranging the boxes and before the child attempted to select the middle-size box in the new position, the examiner called his attention to the problem by saying: "Remember, the toys is always under the middle-size box." This language is the same as in the initial instructions and was used without variation with each new position throughout the test. The comment upon the child's choice was exactly the same as at the end of the first trial. If he made a second or third choice spontaneously his action was recorded. If he failed and did not make another choice the examiner raised the middle-size box saying: "It's always under the middle-size box."

Before beginning the test on succeeding days the examiner said: "Do you remember how we played our game? The toy was always under the middle-size box. All right, find the toy for me."

A record was kept on a suitable blank form of the number of the box chosen, the hand used in the choice and the general reaction of a child to the test.

RESULTS

The performance of each child on the size relationship test is summarized in table 1 for each series and for all series combined. This table shows the number of practice periods required to learn to select the middle-size box without error on the 15 choices required on each practice period and the number of errors or wrong choices made.

TABLE 1

Number of practice periods and number of errors for individuals on the size relationship test

CHILD	AGE	SERIES								TOTAL	
		1		2		3		4			
		Practice periods	Errors	Practice periods	Errors	Practice periods	Errors	Practice periods	Errors	Practice periods	Errors
Two-year-olds											
	months										
BR.............	23	6	62								
HD.............	23	6	64								
EC.............	26	6	57								
DK.............	27	6	60								
MD.............	27	6	52								
BP.............	27	6	54								
DP.............	28	6	61								
JV.............	28	6	60								
BB.............	28	3	0	3	7	2	2	1	0	9	18
BL.............	29	6	62								
Av............	26.6	5.7	54.1								
Three-year-olds											
CW............	30	7	51	1	0	2	2	2	1	12	54
PF.............	33	4	8	1	0	2	1	1	0	8	9
DM............	34	1	0	1	0	2	2	2	2	6	4
WH............	36	6	37	2	1	1	0	1	0	10	38
AD.............	37	2	7	2	1	2	3	1	0	7	11
AL.............	37	4	12	2	4	1	0	1	0	8	16
CS.............	38	2	1	2	1	1	0	1	0	6	2
JC.............	40	1	0	3	11	1	0	1	0	6	11
HG.............	41	1	0	2	1	3	8	1	0	7	9
BD.............	42	2	2	2	1	2	1	1	0	7	4
Av............	36.8	3.0	11.8	1.8	2.0	1.7	1.7	1.2	0.3	7.7	15.6
Four-year-olds											
ME............	43	5	16	1	0	1	0	1	0	8	16
RH.............	44	2	1	2	1	1	0	1	0	6	2
DD............	44	2	6	1	0	1	0	2	1	6	7
NS.............	46	1	0	3	5	1	0	1	0	6	5
RE.............	49	1	0	1	0	1	0	1	0	4	0
DL.............	50	1	0	2	1	2	2	1	0	6	3
PS.............	51	2	5	2	1	2	2	2	3	8	11
RP.............	51	1	0	1	0	2	3	3	4	7	7
JH.............	51	2	1	1	0	1	0	1	0	5	1
FE.............	52	1	0	1	0	1	0	1	0	4	0
Av............	48.1	1.8	2.9	1.5	0.8	1.3	0.7	1.4	0.8	6.0	5.2

TABLE 1—*Concluded*

CHILD	AGE	SERIES 1 Practice periods	SERIES 1 Errors	SERIES 2 Practice periods	SERIES 2 Errors	SERIES 3 Practice periods	SERIES 3 Errors	SERIES 4 Practice periods	SERIES 4 Errors	TOTAL Practice periods	TOTAL Errors
Five-year-olds											
	months										
BH	56	1	0	1	0	2	1	2	1	6	2
GG	60	1	0	1	0	1	0	2	1	5	1
AW	60	2	1	1	0	1	0	1	0	5	1
MK	61	2	2	1	0	1	0	2	1	6	3
BV	62	1	0	1	0	1	0	1	0	4	0
GD	63	1	0	1	0	1	0	2	1	5	1
BM	*64*	*3*	*10*	*2*	*1*	*1*	*0*	*1*	*0*	*7*	*11*
DL	64	1	0	1	0	1	0	1	0	4	0
NT	64	1	0	1	0	1	0	1	0	4	0
BR	65	1	0	1	0	1	0	1	0	4	0
Av.	61.9	1.4	1.3	1.1	0.1	1.1	0.1	1.4	0.4	5.0	1.9

Age factor

Table 1 shows that the older children took fewer practice periods to learn the 4 series and made fewer errors in selecting the middle-size box. With one exception the two-year-olds failed to learn the first series and were dropped after 6 trials according to the arbitrary standard previously described. For series 1 the 10 children in this group made 541 errors. All of the three, four and five-year olds learned the 4 series. For these children table 2 gives the number of practice periods, the number of errors, the means, the medians, and the ranges for the 4 series combined.

Table 2 brings out the fact that the number of practice periods, the number of errors, the means, the medians, and the ranges consistently decrease in size with the older children thus indicating marked age differences.

The correlation between chronological age and practice periods for the 30 children, ages three to five inclusive, was −.68 ±.07. The correlation between chronological age and number of errors for the same children was −.43

TABLE 2

Number of practice periods and number of errors for age groups on the size relationship test

	THREE-YEAR-OLDS Practice periods	THREE-YEAR-OLDS Errors	FOUR-YEAR-OLDS Practice periods	FOUR-YEAR-OLDS Errors	FIVE-YEAR-OLDS Practice periods	FIVE-YEAR-OLDS Errors
Total	77	158	60	52	50	19
Mean	7.7	15.8	6.0	5.2	5.0	1.9
Median	7.0	10.0	6.0	4.0	5.0	1.0
Range	6–12	2–54	4–8	0–16	4–7	0–11

±.10. These coefficients indicate a definite tendency for both the number of practice periods and the number of errors to decrease as the age of the child increased. However, the indi-

vidual differences within any age group were very large as table 1 indicates. For example. D. M. in the three-year-old group did not make an error on series 1 whereas W. H., although approximately two months older, made 37 errors on this series.

Mental age factor

Mental ages were available only for the two and three-year-olds. Using the rank-difference method, correlations were computed for the 10 three-year-olds to show the relation of metal age to ability to learn to select the middle-size box. The following correlations were obtained:

	PRACTICE PERIODS	ERRORS
Chronological age..........	−.54	−.47
Mental age.................	−.74	−.69

These results can only be taken as suggestive but they indicate that mental age was more important than chronological age in ability to learn to select the proper box.

Analysis of errors

On the average, fewer errors were made on each successive series that was presented to a child. Of a total of 247 errors made by the 31 children who completed the 4 series, 169 were made on series 1, 36 on series 2, 27 on series 3 and 15 on series 4. Thus 68 percent of the total number of errors were made on series 1. This shows that in general when a child learned to perform correctly in the first series the performance in the succeeding series was with few or no errors. The cases of child W. H. and child C. W. illustrate this. W. H. made 37 errors before leaving the first series. Thereafter he made but one error. C. W. made 51 errors on the first series, but having learned it he made only 3 errors thereafter. However, there were a number of individual exceptions. J. C. H. G., N. S. and B. L. made no errors until the second series was presented; R. P., B. H., and D. M., made none until the third series; G. D., and G. G. made none until the fourth.

In some cases errors were evidently due to choices being made too hastily. For example, B. H., in the five-year-old group, made 1 error on the third series and 1 on the fourth. In each case his choice was the former middle-size box which he selected quickly. He recognized his error at once and in each case made his succeeding selections without hesitation. Other children probably learned to make the correct choice in series 1 through observing the demonstration but their perception of the relation existing among the boxes was not clear enough to guard them from future errors. Or, again they may have learned to select a particular box during the demonstration, which led them to choose incorrectly in the following series.

It may be, that during training a child learns to react to the middle-size box in relation to the 2 other boxes and also to react to it as a box of a particular size independent of the other boxes. When the new box is introduced the child is confused because these 2 products of training become opposed to each other, the one favoring the choice of the middle-size box in the new series and the other the choice of the largest box which was

the middle-size box in the preceding series. In some cases the larger box will be chosen a few times until the correct box is learned—or the confusion may lead to the choice of the small box instead of either of the boxes to which the products of training have been attached.

Unless the size relationship of the boxes is perceived as an abstraction this difficulty may occur when each new series is presented. Those who make no errors until series 3 and 4 may experience confusion when the second series is presented, but if they happen to make a correct choice on the first trial, the memory of the particular box selected on series 1 tends to become weakened. They may then make correct choices by selecting the proper box because of its particular size just as they did in series 1.

The children who went through the 4 series without an error evidently learned the size relationship as an abstract principle during the demonstration.

Many of the errors occurred when a child formed the habit of choosing the box by its position alone and not by its size. Thus some children consistently chose the box to the right, or to the left, or in the middle position and persevered in this habit in spite of their failure to discover the toy.

Omitting the demonstration trials and those trials when the younger children could not be induced to designate a box because they had not yet learned that the toy was under a box, the children who failed the test had altogether 684 trials. If we consider as systematic choosing only those cases when a choice on the basis of position was adhered to for at least 3 successive trials, we find that 353 choices or 52 percent of all the choices of this group were made on the basis of position. B. B., the only child in the two-year-old-group who completed the test, made no choices on the basis of position. This behavior was found very rarely among the oldrer children. B. P. in the two-year-old-group is an extreme example of the tendency to choose on the basis of position. He chose the box in the middle position 11 out of 15 trials during the second practice period. In his third practice period he chose the box to his left 12 out of 15 trials. During the fourth practice period he chose the box to his left on the first 7 trials and the box in the middle position on the remaining 8. In the fifth practice period he chose the box to his right the first 7 trials, the box in the middle the next 3 and the box to his left on the last 5 trials.

Table 3 shows that confusion of the correct box with the largest box occurred twice as often as with the smallest. Of a total of 247 errors made by the 31 children who completed the test the largest box was chosen 165 times and the smallest 82.

A. J. Kinnaman (1) reported that in learning to discriminate among 6 food boxes of varying size his monkeys were confused by far the greater number of times by the larger boxes. He suggests that this may either be because the larger form could contain more fruit and so seemed more desirable, or that the larger boxes were chosen simply because they were more conspicuous because of their size.

The first of these suggestions does not seem to apply very well to the present study. In the first place, size

of toys is not a factor influencing their choice by young children, especially toys representing live objects which are very large. In fact the children seemed charmed by the small size of the toys. Also there were many comments about the smaller boxes when they were introduced. It seems likely that some of the errors were made in the later series just because the tiny box had an almost irrestible appeal for some of the children. There were frequently such remarks as: "I love that tiny, baby box."

TABLE 3

Analysis of errors according to size of box selected

SERIES 1		SERIES 2		SERIES 3		SERIES 4		TOTAL	
Large	Small	Large	Small	Large	Small	Large	Small	Large	Small
112	57	22	14	19	8	12	3	165	82

Kinnaman's second suggestion, however, that the largest box is chosen because it is more conspicuous seems quite plausible as applied to this test. It might be thought that the confusion with the largest box occurred because that box was remembered as the correct box from the previous series. That may be the fact in some cases but the errors made on the first series makes this objection implausible. In this series the largest box was chosen 112 times and the smallest 57—practically the same ratio as for the 4 series combined.

Here again individual differences are encountered. Several children were confused more often by the smallest than by the largest box in the first series. It is probable that to these children the smallest box appeared more desirable and so more conspicuous. Several children were much more confused by box number 4 than by number 2 in series 2. These children may have learned to make the correct choice in series 1 through a recognition of the size of the middle-size box which was not well enough remembered to lead to the choice of the big box when series 2 was presented. They may thus have been led to choose number 4 because it was conspicuous by its newness.

Interest

Most of the children accepted the examiner's word that they were playing a game and entered into it with the play spirit. This was especially true of the older children, most of whom were successful from the first. B. M. was the only five-year-old who had any difficulty with the game. On the second day, after making several mistakes, he said: "I'm getting tired." This was, however, the only remark of the kind that he made.

Restlessness seldom occurred except when there had been failure. Frequently there was failure without restlessness which appeared in some cases to be due to determination and in others to be the result of satisfaction with incorrect responses.

The older children were more attentive than the younger. It was very difficult to get the two-year-olds to watch during the demonstration and if there was any delay between trials they would run around the room. In general, their attention was fixed only when they were physically active. The older children were very quiet during the demonstration and with the exception of M. E. and B. M. seemed never to tire of playing.

One of the outstanding differences among the groups was the shift of interest from the boxes and toys as noticed in the two-year-old-group to an interest in the game itself by the older children. All the children liked the boxes and the little toys but the five-year-olds and several three and four-year-olds were interested in their score. Children frequently asked if they were getting as many right as some of their friends. There was very little of this interest among the two-year-olds. The direction of attention probably was an important factor in the general failure of the two-year-olds to handle the situation effectively. As Köhler said of the chimpanzees in discussing his experiment with the "Choice Boxes," instead of looking carefully at the box after making a correct choice with a view of discovering its distinguishing characteristics for future use, they "—were carried away by their immediate interest in the goal before them—."(2)

SUMMARY

A study was made of the behavior of 40 children between the ages of two and five years in learning to choose the middle-size box in a series of 3 boxes varying proportionately in size. After the child had learned to make the selection correctly in the first series, the largest box was replaced by one smaller than the 2 remaining boxes and he was again asked to select the middle-size box. This process was repeated through 4 series.

From an analysis of the data thus obtained the following are some of the more pertinent results:

1. The test was beyond the ability of 9 of the 10 two-year-olds used in this study.
2. Fifty-two percent of the choices of the 9 children who failed the test were made on the basis of the position of the box.
3. The 31 children who completed the test gave almost no evidence of selection on the basis of the position of the box.
4. The number of errors and the number of practice periods required to learn the 4 series decreased with age.
5. Success in learning the test was correlated highly with mental age for 10 three-year-old children.
6. Direction of attention to the boxes and interest in making correct choices were factors in success.
7. The 31 children who completed the test confused the middle-size box with the largest box in a series twice as often as with the smallest one.
8. Sixty-eight percent of the errors made by the 31 children who completed the test were on series 1. This indicates that the children learned to select the middle-size box in relation to the other boxes rather than to select a particular box. Once having learned the concept of "middle-sizeness" on the first series of boxes they were able to apply this concept to succeeding series.
9. There were large individual differences in learning.

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Racial Differences in Bi-Manual Dexterity of Latin and American Children

EMILY O. LAMB

IN TESTING Latin and American children with the Stanford revision of the Binet-Simon tests, over a period of ten years, the writer arrived at the conviction that Latin children are more dexterous with their hands than American children; so this investigation has been undertaken to prove or disprove that belief.

Hollingworth and Poffenberger (5) in discussing form-board studies of different races, made by Woodward, (15), ask, "are there characteristics of mind peculiar to different races of men, which need to be considered from the point of view of efficiency?" There is "practically no attempt to separate the facts of inheritance from the effects of education, customs and general environmental conditions." "Experiments have been made on rather simple functions, such as sensory acuity, motor ability and simple judgments. Although the traits are simple, yet they are characteristics in which peoples are supposed, in the popular minds, to differ. The upshot of all the experimental tests seems to show that the racial differences in fundamental qualities, independent of training, are slight."

Woodward (15) considered the form-board test he used to be a fair test of intelligence, and depending very little on training. He found "between whites, Indians, Eskimos, Ainus, Filipinos and Singalese, the average differences were small and much overlapping occurred." But between these groups and the Ingorot and Nigroto from the Philippines and a few Pigmies from the Congo, the average differences were great and overlapping was small. Woodward says that the results would seem to indicate differences in intelligence, but as the fairness of the test is not beyond question, it may have been a more unfamiliar sort to these wild hunting folk than to the more settled groups.

Herrick's (4) studies of Brahman and Panchama children in South India, bring out interesting points on the question of physical maturity. At four years Brahman children exceeded American children in quickness of reaction, but at five years the American children have caught up, and from six years on the American children hold the lead, being faster at every succeeding age studied. Herrick gives as one of the causes that in the tropics children mature earlier than in colder climates, so it is not surprising that four year old Indian children should be capable of faster performance than American four-year-olds.

Paschal and Sullivan (10) gave a series of standardized performance

tests to Mexican children to attempt to determine racial differences in the mental and physical development of Mexican and American children. They found considerable overlapping in the top third of the distribution of most tests, but from the median downward the American children show increasing superiority, the difference being greater at nine years than at twelve. Less sex difference is found in Mexican children than in American children on performance tests.

Koch and Simmons (8) in an experimental study of American, Mexican, and Negro children, found that the city white children are younger, in grade for grade comparisons, than are the city Mexicans. That the city groups, whether American or Mexican, are younger for their grades than are their respective rural groups.

Murdock (9) studied 3 different racial groups in Hawaii, the Chinese, Japanese, and Korean, and found that the Chinese and Koreans were superior to the Japanese in tests involving language but in the Beta test the superiority of the Japanese is clearly shown.

Seashore (13) makes the statement in his "Psychology of Musical Talent":

> "Thus we find among children those who are slow and sure, slow and erratic, quick and sure, quick and erratic, and no one seriously expects these tendencies to be altered any more than he expects the leopard to change his spots. These permanent peculiarities we call 'the personal equation.' Reymert (12) carried out a study of a series of reactions of various muscle groups, to validate Seashore's claim, on the assumption that if the personal equation existed, it would manifest itself within recognizable limits. His conclusions were that 'a distinct personal equation for speed exists,'—with the reservation, however, that this personal equation is to some extent a different one for instantaneous motor performances than for motor performances of a continuous nature."

Other findings, which seem to indicate a "personal equation" are requoted by Ream (11). In an experiment on tapping rates, he states that,

> "Every individual has his own motor set-up, one is geared slow, and another geared fast, the chief factor—is probably a physiological openness of nerve paths which is inherited. The extended practice experiments of this study seemed to indicate that the test measures fundamental basic abilities since improvement was, on the whole, conspicuously lacking. The inference is that the motive neural set, undoubtedly an important condition of such basic ability, is inherited."

Among experiments employing but one hand at a time, is a very extensive and painstaking study by Wellman (14) on the Development of Motor Coördination in Young Children. Some of the results of her study of motor coördination are recorded as follows: There were no sex differences in the scores on either test. The scores at six years nearly doubled those made by the three-year-old children. Movements with the left hand were more difficult than movements with the right hand, and the differences with the 2 hands became greater as age increased. Children who made more accurate movements with the right hand, than others in the group, also made more accurate movements with the left hand.

As early as 1892 Bryan (1) invented a very complicated tracing-board which he used to considerable extent. Among the conclusions he reached was that the maximal rate of move-

ment probably furnishes a test of the general condition of the central nervous system, of the nerve centers by which the muscles involved in the movement are controlled. He estimated that the rate of the child of six years was two thirds the rate of the youth of sixteen. Girls excell boys at thirteen years but are inferior at all other ages.

PROBLEM, TESTS, AND SELECTION OF SUBJECTS

During the teaching and supervising of art in schools in California some years ago, I found, especially in the low elementary grades, little difficulty in interesting both Italian and Mexican children in the subject of clay modeling and other hand work, such as basketry. Moreover Mexican children seemed unusually deft in handling clay and frequently turned out much more interesting results than did American children.

Later, in giving Binet tests to mixed groups, I found that the California Spanish, Mexican, and Italian children seldom failed on such tests as the tying of a bow, and the discrimination of weights, while the American children often failed to score a plus on those tests. Whether these differences are chance, environmental or real differences in ability is a problem upon which little conclusive experimental work has been done.

The purpose of this investigation is to study the results of certain manual processes given to groups of American and Latin childen with the hope that it may throw some light upon the question as to whether there are racial differences in bi-manual ability or whether it is a traditional attitude with some persons to expect Italian and Mexican children to be more gifted manually than American children.

Selection of tests

The tests in this study do not in any way represent a scale of performance tests, such as the Pintner-Paterson scale. Although the 11 tests used do not all require the actual use of both the right and left hand, the tests have been so arranged that the activity or passivity of the left hand was always observed and noted. The chief thought was to choose tests that would be simple and thus avoid discouraging young children, ranging from four years, nine months to seven years, nine months. Another consideration was to find tests that would contain somewhat familiar processes and would be attractive; and it was necessary to make a selection that would require only the simplest directions in order to be certain that the foreign children understood the requirements; moreover the desirability of arranging a group that could easily be completed in one hour or less to avoid fatigue and its consequent inertia and loss of interest was paramount.

As it seemed desirable to have some definite method of getting at the mental status of the subject, and as it would have consumed too much time to give each one a Binet test, two tests were finally decided upon: one was the Goodenough (3) test of "The Measurement of Intelligence by Drawings," the other was a set of picture puzzles based upon Rossolimo's "profile method," which ac-

cording to Johnson (6), Rossolimo designated as a test in the "capacity to combine."

Age and race groups

The ages of five, six, and seven were chosen because it was desirable to select children who had been given little instruction in manual processes. Those ages could be easily obtained in the public schools. The average ages were as follows: Baltimore Americans, 6 years 6.6 months; San Diego Americans, 5 years 7.5 months; Sicilians, 7 years 1.1 months; Mexicans, 6 years 2.8 months.

Social status

The Italian children studied were all Sicilians, found in a city school of Baltimore which was entirely made up of Sicilians. The neighborhood was *dirty and ill-kept. The school also* was in harmony with the district, with its small, dusty, windswept yard: but it had a corps of enthusiastic teachers; women who were studying their district conditions and endeavoring to better them. The school nurse had gained the confidence of these suspicious and superstitious people, and was doing excellent work with mothers in inducing them to allow corrective and preventive work to be done. Nearly all the children were wearing various amulets around their necks, and one child was wearing the same dress for a year, without having it washed, because the grandmother had promised that she would, if her younger sister lived through a severe illness. The children looked undernourished, many with obvious physical defects. This group was by far the lowest type group studied, and could not compare even with the poorest of the Mexican or San Diego American group.

The determination of what constituted an American child was based upon the fact that the parents, and, as far as I was able to determine, the grandparents were born in America. A group of 52 American children in one of the most exclusive residential districts of Baltimore was tested. Their school was new, beautifully equipped with every modern convenience to do an advanced type of school work. The children in the kindergarten changed to tennis-shoes on coming in doors, and all were taught to tie their own shoe-strings, so their score on this bow-knot test was high. Because of the very different social status and environment of this group in comparison with the Sicilians and *Mexicans, I have used another American* group, whose school and home conditions were more nearly comparable for correlations with the foreign groups.

The other group of American children was selected from the same school that the Mexicans came from, and were children living in the same neighborhood as the Mexicans, and in comparable limitations of income and housing. The average age of this American group was 5 years 7.5 months, while the average age of the Baltimore group was 6 years 6.2 months. In none of these studies did I find any group living in the squalor and poor housing that I found the Sicilians living in. Not that such conditions for other nationalities possibly could not be found, but, living for the Mexicans, for instance, in Southern

California does not offer the problem of over-crowded cities and lack of space and the closing of houses to fresh air in winter, that such a city as Baltimore offers. However, Goodenough (2), in comparing the living conditions of Chinese and Japanese in California with Italians, states that social pressure of "race prejudice" is often urged as a reason for the segregation of certain racial groups within poorer neighborhoods; but that

"it should be remembered that while racial prejudice may bring about segregation, the character of the neighborhoods thus set off is primarily dependent upon the people living in them. It is doubtful whether even the southern Negro has more to contend with in the way of this prejudice than the Chinese or Japanese in California; yet the contrast between the typical Oriental neighborhood and the Italian (or Negro) district is marked. Poverty there may be, but the squalor which is characteristic of the Italian (and the Negro) sections is lacking."

The Mexican children were all the first generation born in the United States. The group of Mexicans represented in this study was tested in one of the San Diego Public Schools, located in a Mexican district, while a few were taken from kindergartens in Santa Barbara. In each class, however, the entire group of five, six, and seven year old children was examined. The San Diego school building was very much like the one in Baltimore where the Sicilians were housed, but it was augmented by many bungalows in the school yard. In these were held the lower primary and kindergarten classes. The yard was inadequate in size and equipment, but because of the mild climate, all the physical exercises were done out of doors, as well as many class recitations and activities.

The numbers in the groups tested are nearly equal: Sicilians 55, Mexicans 53, San Diego Americans 50, and Baltimore Americans 52. The sexes are unequally divided, for it seemed a less selective method to take all the children of the three age-groups in the classes, than to take the same number of girls as boys. So the groups run: Sicilian boys 24, girls 31; Mexican boys 18, girls 35; San Diego American boys 22, girls 28; Baltimore American boys 26, girls 26.

ORDER OF TESTS

Careful consideration was given to the order of presenting the tests; since the series took an hour to give, fatigue and loss of interest had to be avoided.

The following order was finally decided upon as it seemed to offer the maximum of variety in those to be performed while standing and those performed sitting:

Peg board	standing
Drawing of man	sitting
Tying of bow	sitting
Goddard formboard	standing
Nut and bolt	sitting
Buttoning of belt in back	standing
Peg board in colors	standing
Threading of needles	sitting
Motor coördination	sitting
Picture puzzles	sitting
Stringing buttons	sitting

DRAWING OF A MAN

For the Goodenough Drawing test the child was given a 9 by 12 inch sheet of drawing paper and a large soft pencil; the directions were as follows: "On this paper I want you to

TABLE I

I.Q. score in the test of the drawing of a man

	C.A.	M.A.	I.Q.
	Mexican		
	Boys		
1	5-3	6-3	119
2	5-4	6-6	122
3	5-4	5-0	99
4	5-4	5-6	103
5	5-7	4-9	85
6	5-11	8-3	140
7	6-0	6-9	102
8	6-0	7-3	121
9	6-1	7-9	127
10	6-1	6-9	111
11	6-5	6-3	97
12	6-6	5-6	92
13	6-7	5-9	88
14	6-7	10-0	147
15	6-8	6-9	101
16	7-0	7-0	100
17	7-0	9-6	135
18	7-1	7-6	105
	Girls		
1	4-9	6-0	126
2	4-10	5-3	108
3	5-0	6-0	120
4	5-0	5-9	115
5	5-0	5-3	105
6	5-0	6-0	120
7	5-0	6-3	125
8	5-2	6-0	116
9	5-3	6-9	128
10	5-3	5-9	109
11	5-4	6-9	126
12	5-5	7-3	134
13	5-7	5-3	94
14	5-8	7-0	123
15	5-8	7-6	133
16	5-9	7-3	126
17	5-9	5-3	91
18	5-11	6-9	114
19	5-11	6-0	101
20	5-11	7-6	127
21	5-11	6-9	114
22	5-11	5-0	85
23	6-0	6-6	108
24	6-0	6-6	108
25	6-1	7-3	119
26	6-2	5-3	85
27	6-4	10-0	170
28	6-7	7-3	111
29	6-7	7-0	106
30	6-7	6-0	92
31	6-9	9-6	140
32	6-11	5-3	76
33	7-0	6-6	93
34	7-5	6-6	87
35	7-6	7-0	93
	Sicilian		
	Boys		
1	4-10	6-0	123
2	5-5	7-0	128
3	5-9	6-6	112
4	6-1	8-9	143
5	6-5	5-0	73
6	6-5	5-3	82
7	6-5	6-3	97
8	6-5	7-9	120
9	6-7	5-0	76
10	6-7	6-3	95
11	6-7	6-9	102
12	6-7	5-6	84
13	6-7	7-3	110
14	6-7	5-9	87
15	6-10	7-6	110
16	7-0	5-9	82
17	7-0	5-9	82
18	7-1	5-6	78
19	7-1	5-3	74
20	7-2	7-3	101
21	7-2	9-0	125
22	7-3	6-6	89
23	7-3	8-6	116
24	7-3	6-6	90
	Girls		
1	4-6	5-0	111
2	5-3	5-6	105
3	5-7	7-0	125
4	5-8	7-0	123
5	5-9	5-9	100

TABLE 1—*Continued*

	C.A.	M.A.	I.Q.
	Sicilian—Concluded		
	Girls—*Concluded*		
6	5-9	6-6	113
7	5-0	7-9	135
8	5-0	6-0	104
9	5-10	6-0	103
10	5-10	6-3	107
11	5-10	5-9	98
12	6-3	6-9	107
13	6-3	7-0	120
14	6-4	6-0	102
15	6-4	7-0	110
16	6-5	10-0	155
17	6-7	6-0	80
18	6-7	6-6	00
19	6-0	5-3	78
20	6-10	6-9	98
21	7-0	7-0	100
22	7-0	7-3	104
23	6-7	6-0	02
24	6-8	5-9	86
25	7-0	6-0	86
26	7-1	6-9	05
27	7-1	5-6	78
28	7-3	6-6	80
29	7-4	9-0	122
30	7-4	7-6	102
31	6-8	6-3	94
	San Diego American		
	Boys		
1	4-11	6-3	126
2	5-0	5-0	100
3	5-2	4-6	87
4	5-4	5-4	100
5	5-4	5-3	98
6	5-4	5-0	107
7	5-4	5-0	93
8	5-4	5-0	107
9	5-7	5-3	94
10	5-9	4-9	84
11	5-9	4-9	83
12	5-11	6-6	110
13	5-10	6-6	103
14	6-0	6-0	102
15	6-1	6-9	111
16	6-5	5-9	90

	C.A.	M.A.	I.Q.
	San Diego American—Concluded		
	Boys—*Concluded*		
17	6-7	7-0	106
18	6-7	6-6	99
19	6-9	6-6	96
20	6-9	7-0	103
21	6-10	4-9	70
22	7-1	6-6	93
	Girls		
1	4-6	5-6	122
2	4-7	6-0	130
3	4-10	4-3	87
4	5-0	5-3	105
5	5-0	6-3	125
6	5-2	4-6	87
7	5-2	5-3	101
8	5-3	6-3	119
9	5-3	6-0	114
10	5-4	5-9	107
11	5-5	6-6	120
12	5-6	5-6	100
13	5-6	7-3	133
14	5-7	7-6	135
15	5-8	5-0	88
16	5-9	5-6	96
17	5-9	6-9	117
18	5-9	4-6	79
19	5-11	5-6	93
20	6-0	7-3	121
21	6-0	4-6	75
22	6-0	6-9	112
23	6-2	5-6	90
24	6-2	5-3	85
25	6-4	7-0	110
26	6-8	6-9	101
27	6-9	6-6	96
28	7-1	5-6	78
	Baltimore American		
	Boys		
1	5-5	3-9	69
2	5-5	5-9	106
3	5-7	5-6	98
4	5-7	7-0	125
5	5-7	8-0	143
6	5-9	6-6	112

TABLE I—*Concluded*

	C.A.	M.A.	I.Q.
Baltimore American—Concluded			
Boys—*Concluded*			
7	5–9	6–9	117
8	5–11	7–9	131
9	6–0	7–6	125
10	6–2	6–0	97
11	6–3	7–0	112
12	6–3	6–3	100
13	6–4	6–0	95
14	6–5	5–9	89
15	6–8	6–0	90
16	6–8	4–0	60
17	6–9	6–6	96
18	6–9	6–6	96
19	6–9	5–6	81
20	6–9	6–9	100
21	6–10	6–3	91
22	6–11	6–9	97
23	7–1	5–6	78
24	7–3	6–0	83
25	7–3	8–0	110
26	7–5	6–9	91
Girls			
1	5–1	5–3	102
2	5–3	7–9	147
3	5–4	6–0	113
4	5–5	5–3	97
5	5–7	7–0	125
6	5–7	6–0	108
7	5–8	8–0	135
8	5–10	6–6	111
9	5–11	10–6	176
10	6–0	6–3	104
11	6–0	7–9	128
12	6–0	6–0	100
13	6–3	6–6	104
14	6–7	6–9	102
15	6–8	6–0	90
16	6–9	6–0	89
17	6–9	6–0	89
18	6–10	7–0	103
19	7–0	6–6	93
20	7–1	6–6	92
21	7–2	8–3	142
22	7–4	6–6	88
23	7–7	7–6	98
24	7–8	9–0	117
25	7–9	11–0	142
26	7–2	8–3	115

make a picture of a man. Make the very best picture that you can. Take your time and work carefully."

Some of the children had to be encouraged to make a start but not a child refused to make the drawing. Many of the American children chatted all the time they were drawing, naming each part as they put it in. This chatting was not so voluble with the foreign children, although they commented on an item now and then.

Over 77 per cent of the total test of the Drawing of a Man by the 53 Mexican children gave a higher mental age than the chronological age of the child; 58 per cent of the Sicilians, 56 per cent of the San Diego Americans and 60 per cent of the Baltimore American group.

The drawings made by the Sicilian group were unlike those of the other groups in that they contained much more anatomical detail. Very often a circle or elipse across the middle of the trunk was "the belly." The navel was often represented. These drawings were, on the whole more dramatic than those of the other groups. The man would be running, or raking, or smoking, or even shooting. One man had a large pistol in his pocket. The fact that they were drawing "a man" was evidently seldom remembered by any of the children, for when they clothed him, he was just as liable to be wearing a dress as coat and pants. The incongruities seemed to be unrecognized by most of the children: the fact that the man was wearing nothing but a tie or hat with no other clothing received no consideration.

It is a notable fact that the difference in social satus and type of environment of these groups is clearly shown by the comparison of the drawings of

the Sicilian group, who came from very poor and ignorant homes, with the drawings of the American group studied in Baltimore. In the latter group more clothing is shown, and such things as golf-sticks and canes and umbrellas were depicted. One drawing is of a "Pilgrim." In not one is the stomach drawn nor the navel. In the drawings of the Sicilian children fewer show clothing, and when the man carries something, it is usually a gun. One child, when he was finishing, put a vertical and horizontal line across the trunk; when asked what it was he said, "The cross of Jesus." Another child, after finishing the drawing of the man, drew a series of vertical lines in the space to one side. I asked what that was, and he said, "Macaroni for the man to eat."

One Mexican child drew a man with six fingers, a line out from each finger and a circle on the end, this was a "balloon man." Such comments as "he's running," "he's shooting a gun," would come from the foreign children, but the American children often told a whole story about their drawings as they progressed. Only a few children, in any of the groups, drew profile; almost all were front view. In a few cases the children drew the man upside-down through-out the entire test, but in all cases, when they had finished they turned the drawing around to the correct position. Quite a number began with the legs instead of the head.

In over two hundred drawings only one could be said to show what Goodenough (3) terms "flight of ideas." The arms and hands were like feather dusters and were huge as compared with the size of the rest of the figure. The feet were like lily-pads with lines like the veins of the leaves, running out from where the legs form the feet. The head was mostly hair. This child was five years, four months old, and was considered a great problem in school. She showed little ability to give attention and was erratic and unable to follow directions. The mother was much troubled about her, but the mother also showed a high degree of nervous tension, was very anxious and extremely talkative.

The only other drawing that was unusual was done by a boy of five years, five months. This consisted of an oblong with 2 circular scribbles in the right half, joined to another small oblong. When asked what these were, he said, "Eyes, mouth, nose, big feets." The "big feet" were the sides of the smaller oblong. This drawing does not come into the class showing indications of psychopathy, however, but simply shows unusual immaturity. He was a tiny, very babyish child in looks and in speech and made a mental age by the drawing test of three years, nine months. Both these children were in the socially highest-type group.

Left hand

After the drawing of a man was completed with the right hand (only 3 preferred the left hand) then the picture of a man was drawn with the left hand. Many of the children did not hesitate, but put the pencil into the left hand and started drawing at once, but others said "I can't;" one child said, "I'll make a funny man." For many of the children the change

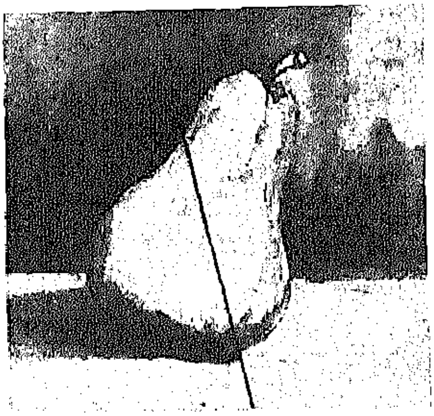


FIG. 1

FIG. 4

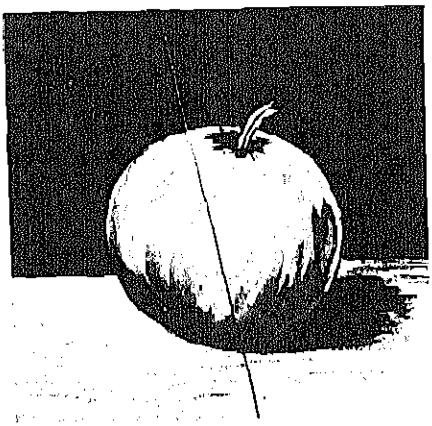


FIG. 2

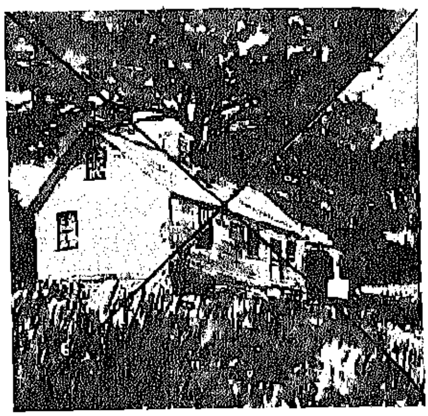


FIG. 5

FIG. 3

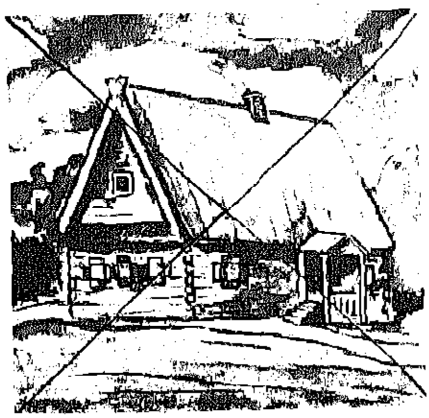


FIG. 6

Fig. 7

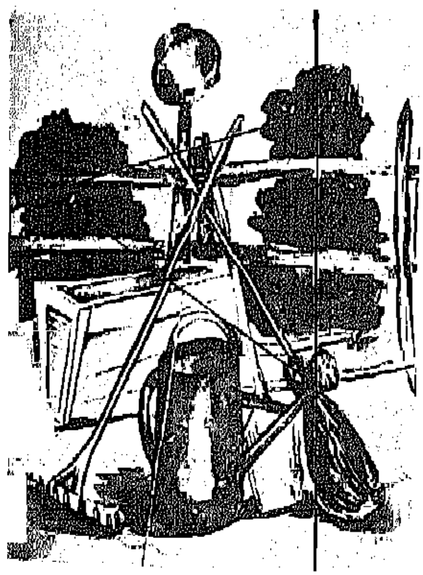


Fig. 8

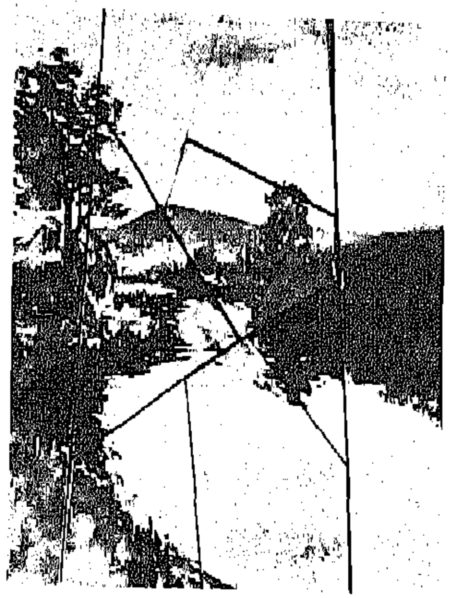


Fig. 9

Fig. 10

was so awkward that they had to make a great effort to do it. One child put his tongue in his cheek, several "chewed their tongues." There were a number of children who appeared to use the left hand as easily as the right. They showed fairly good motor-control; the lines were firm and the joining of lines good.

In most of the cases where the use of the left hand seemed so difficult, the right hand would go over to the left again and again to help, especially when it came to the drawing of the features and other details. Without seeming to realize it, the child frequently changed the pencil back to the right hand. For the most part, those who found the left hand drawing difficult would hold the pencil with fingers far back from the point, or would hold it with a fist-like grip and press down hard upon the paper.

There were children who appeared to be ambidextrous and who seemed to enjoy using the left hand. One of these children, when making the first drawing, would use the right hand to work on the right side and would change the pencil to his left hand when drawing the details of the opposite side of the picture. In most cases the use of the pencil for drawing with the left hand was difficult. The position of the hand in holding the pencil was awkward and the motor-control much poorer than when the right hand was used. The opposite was true for two of the children who were left-handed.

PICTURE PUZZLES

The picture puzzle test was placed as the eleventh in the last of performance tests, but since it was based upon the Rossolimo test that was designed to measure mental capacity the discussion of it is given here in order to compare it with the standardized test of Goodenough (3). This test has not been standardized, nor are there norms for the Rossolimo.

This test consists of a graded series of 10 pictures 6 by 6 inches done in water-color, mounted on fourply veneer, shellaced and cut. The subjects are similar to the Rossolimo series but substitutions have been made for the 5 familiar objects that seemed to the writer to be more attractive to young children than Rossolimo's, and the 5 geometric figures that are black on a white ground in the Rossolimo, have been changed to color. The circle is red; the square, orange; the oval, purple; the snake-like design, two tones of green; and the star, two tones of blue. As the Rossolimo series is copied in water-color and the white water-color paper soils so quickly the substitute set is protected by shellac. Otherwise one set of dissected pictures might not have lasted through the experiment. This process has somewhat changed the character of the color, yellowing the whites, and mellowing the brilliancy of the colors. It is just possible that had picture varnish been used there would have been a little less change in the color. The 10 pictures are cut in the same shapes as those of the Rossolimo series.

The five that have been changed as to subject are shown in the accompanying photographs. For the geometric figures see Johnson (7).

One reason for putting this series toward the end of the gamut of tests

was the thought that the performance took a much longer time than any other single test and that it might be discouraging if given toward the beginning. Then, too, the child tested would be better acquainted with the examiner and more at ease, and so would be likely to make a better pro-

was kept with a stop-watch; 3 minutes being the limit of time allowed for each picture.

The method of procedure, was similar to Johnson's in stopping the test after 2 successive failures were made. In a few cases she allowed the child to try other pictures after 2 failures, but

TABLE 2

Scatter of failures in picture puzzle test

PUZZLE NUMBER	5 YEARS				6 YEARS				7 YEARS				TOTALS			
	Mexicans	Sicilians	San Diego Americans	Baltimore Americans	Mexicans	Sicilians	San Diego Americans	Baltimore Americans	Mexicans	Sicilians	San Diego Americans	Baltimore Americans	Mexicans	Silicians	San Diego Americans	Baltimore Americans
	Number of children															
	21	11	28	14	25	25	10	23	7	10	3	15				
1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	0	1	3	0	1	0	3	0	0	0	0	1	1	1	6
4	1	2	2	5	2	2	0	2	0	1	1	0	3	5	3	7
5	4	5	12	6	0	7	0	5	0	0	0	2	4	21	12	13
6	1	1	4	4	3	4	2	5	0	1	0	0	4	6	6	9
7	10	8	17	0	8	10	0	12	0	8	0	5	18	35	17	20
8	8	5	18	12	7	10	8	10	1	11	2	7	16	35	28	35
9	21	11	28	13	23	22	19	23	7	19	3	13	51	52	50	40
10	20	9	27	14	17	23	16	22	5	18	3	13	42	50	46	49
Total....	60	42	100	66	60	97	35	88	13	67	9	40	130	206	163	194

longed response. Experience with these 212 children makes me conclude that this was probably a wise decision.

Procedure

The pieces of the pictures were placed in the same order for presentation as that given by Johnson (6) but the instructions were slightly changed, and were as follows: "This is a picture that has been cut into several pieces, see if you can put it together again to make a picture." The time record

she states that in no case was the attempt successful.

With the series of pictures substituted in this experiment for those of the Rossolimo series, all the children were allowed to try all of the pictures, stopping the trial at the three-minute time-limit for each picture. The findings differed from Johnson's in the matter of successful scores after 2 successive failures, which leads to the question as to whether the series used in this study is as well graded as the

Rossolimo series. With this possibility, or perhaps probability, in mind, the method of scoring was changed. Instead of considering the score to be the "number designating the place in the series of the final picture which is correctly solved," (after 2 successive failures), the aggregate of all the correctly solved pictures was used as the score. This lowers the score in some cases where the final result showed much scattering.

The scores given in table 2 show the extent of scattering. Although the burden of failures is found on puzzles 9 and 10, yet it also shows that quite a number of individuals succeeded with picture 10 who failed with 9. As picture 9 is one of the substitutions for the Rossolimo pictures, it may be that the one used in this study presents more difficulties than number 9 of the Rossolimo series.

In table 3 showing the distribution of scores, the Mexican group is far in advance of all the other groups in the number of high scores, the aggregate being 8 for score 9, and 1 for score 10. Neither the San Diego American group nor the Sicilian group had a score of 10; the Baltimore American group shows one such score.

TABLE 3

Distribution of picture puzzle scores

SCORE	5 YEARS				6 YEARS				7 YEARS			
	Mexicans	Sicilians	San Diego Americans	Baltimore Americans	Mexicans	Sicilians	San Diego Americans	Baltimore Americans	Mexicans	Sicilians	San Diego Americans	Baltimore Americans
0												
1												
2								1				
3	1			3								
4	2	3	4	2		4	1	2		1		
5	3	4	5	2		4		3		1		
6	2		10	4	1	10	3	7		5		4
7	9	3	9	3	6	5	3	3	1	7	2	2
8	11	3	4	3	6		7	6	2	3		5
9	1	1			4	1	2	1	3			
10					1							1
Total....	29	14	32	17	18	24	16	23	6	17	2	12
Average ..	6.7	6.0	6.1	5.7	7.8	5.8	7.9	6.8	8.3	6.5	7.0	7.3

It was notable throughout this test that during the first of the series, where the picture was relatively simple for most of the children the stimulus-pattern was the picture represented, but as the picture became more complicated, they began to work to fit shape rather than design.

In the case of the Mexican boy who had a score of 10, picture-design was his motive throughout. In puzzle 9, he said, "This is a house and it's near the water." In the star he systematically put the corner squares to-

gether, making the design match; then he put the four squares together, clearly showing that the picture pattern was what he was working for. One little girl who also worked for design throughout said, "The sky is at the bottom of the picture, too;" referring to the reflection of the sunset in the water. Many of the children in doing the star-puzzle seemed to work for pattern, but were satisfied with a very irregular picture-pattern result. Some of the younger children showed the tendency that Johnson (6) reports: In putting the third picture together, they would put the pieces in a row and say "Baby;" or perhaps they got three pieces together correctly, then put the fourth in in whatever way it happened to lie on the table, and were satisfied with the result.

When the San Diego groups were examined it was near Easter, and many of the children at once said, "It's an Easter egg" when they correctly solved the puzzle with the oval pattern. The majority of the children named the pattern as soon as they had the pieces put together correctly. The red circle was usually called "a red apple." Twice the orange square was called a "handkerchief" by girls. Some of the children would get pieces together correctly, not recognize the fact and pull them apart again. This was especially true of the snake-like pattern. One little girl who failed on this test said, "That is a hard one, looks like a round snake." One child said of the oval, incorrectly assembled, "It's a water-bottle." One boy who had a score of 4, never did seem to get the real idea of assembling for a pattern. He shoved the pieces around with no apparent idea of what he was working for. This was a San Diego American boy. It was surprising at times how satisfied a child would be with a perfectly incongruous and irregular grouping. One unsuccessful little girl of the Baltimore American group said, "Gosh, I think this is fun!" There were some who, after the first one, used a "trial and error" method throughout the test. One of the Sicilian group made a score of 9, using this method.

PLAIN PEG BOARD

The first test given was a peg board. This board is of varnished maple, with pegs to match. The size is 12 by 12 inches with 36 half-inch holes, 6 on a side, equidistant, leaving a margin of $1\frac{1}{2}$ inches. The pegs are 3 inches long and $\frac{7}{16}$ inches in diameter, with the edges of both ends beveled to prevent the peg from chipping and from being difficult to slip into the hole.

The pegs were in a shallow pan at the right of the board (at the left, if the child were left-handed). The table was low, so the child looked down upon the board as he stood in front of it.

The directions were: "Put your left hand (indicating it) on the lower corner of the board, and with the other hand put all these pegs in these holes just as fast as you can, picking up only one peg at a time. Ready, go!" The time was kept with a stop-watch.

Most of the children began to put in rows of pegs beginning at the right side, and either put the pegs in rows from front to back or from back to front; but some worked forward and back all the way across the board in-

stead of starting each new row at the front. Few of them had the idea of starting at the left side and so avoid reaching over those pegs that were already placed. Almost every combination of method was employed; however, the most frequent was in rows from front to back or the reverse, with the exception of the San Diego groups. There were only 2 children who used a hit or miss manner.

The San Diego children, almost without exception, put in all the outer rows of pegs first, then filled in the center either in concentric squares or in rows across. This was the only group of children who used this method; a very few individuals had done so. In talking with the teachers of this group one kindergartener said that in their use of the peg board they generally told the children to put a fence all around the board first.

The averages for all the groups were very close as is shown in table 4.

Both the best and the poorest records appear in the Baltimore group of American children, the best record being 59 seconds. This was made by a little girl of seven years, four months who made a record of ten years, three months on the Drawing of a Man and a score of nine on the Picture Puzzles. However, on the finer coördinations, such as the threading of needles, she was very slow, taking 4 minutes and 30 seconds to thread the six needles. She was left-handed.

All the children who were left-handed were allowed to use that hand. The poorest record was made by a boy five years, five months who took 2 minutes 50 seconds for the test. His rating for the Drawing of a Man gave him a mental age of three years, nine months and his score in the Picture Puzzles was three. His procedure was unlike that of the other childen in that several times he picked up a whole handful of pegs, and was sufficiently distractable to leave the board at one time to ask if we were going "to play a game with those," pointing to other apparatus. He was a tiny, undeveloped child, very babyish in his manner.

In the other 3 groups the highest as

TABLE 4

Average time for peg-board

	BOYS		GIRLS	
	minutes	*seconds*	*minutes*	*seconds*
Mexicans:				
Plain	1	28	1	26
Colored	1	28	1	30
Sicilians:				
Plain	1	23	1	25
Colored	1	32	1	32
San Diego Americans:				
Plain	1	26	1	25
Colored	1	35	1	32
Baltimore Americans:				
Plain	1	20	1	26
Colored	1	30	1	28

well as the lowest records are found in the Mexican group. There were 3 children in this group who took over 2 minutes for this test, the longest record being 2 minutes and 26 seconds. The shortest record was one minute.

There was one child who was so steady in putting the pegs in that her reactions were almost rhythmic. It was difficult, with some of the five year old children to give them an idea of speed. One child of four years,

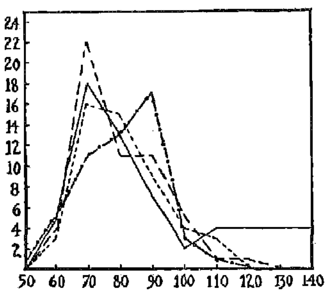


FIG. 1. RELATIVE TIME SCORES. PLAIN PEG BOARD

——— Mexican; — — —Italian; — — — — S. D. American; —●—●— Baltimore American.

seven months stopped to blow her nose, another started to tell me about her baby brother, and held a peg up until she was reminded to hurry. Some of the children were prone to pick up 2 pegs at a time until reminded not to do so. One child did this every time he thought I was not looking. In 2 cases the children had to be urged to "go on," as they appeared to think that after one row was in, the test was finished. One child even started to take the pegs out.

Left hand

All the children who were left-handed were allowed to use that hand instead of the right hand in these tests, in which case the apparatus was arranged with the same relation to the left side of the child as for the right side of those who were right-handed. There were 3 left-handed children, 2 Mexicans and 1 Baltimore American. One of the former appeared to be ambidextrous, especially when using a pencil. At first, when told to "put the left hand on the corner of the board," some of the children would press the left hand down hard until they became interested enough to forget and relax.

COLORED PEG BOARD

Although the Colored Peg Board test is number seven in the list of tests as given, the results of that test will be given here in order to compare them with the results obtained with the Plain Peg Board.

This board is constructed like the other peg board with the exception that it is painted in three stripes of color, one blue, one deep yellow, and one green. Each stripe covers twelve peg-holes, and the twelve pegs belonging in these holes are painted the same color as the stripe.

The directions were:

"Here is another peg board, just like the first one, but in 3 colors, with pegs to match: the blue pegs go into the blue stripe, (illustrate by putting in a blue peg); the yellow in the yellow stripe (illustrate); and the green pegs in the green stripe (illustrate). Put your left hand on the corner of the board and pick up only one peg at a time. Let me see how fast you can put these pegs in the holes where they belong. Ready, go!"

Most of the children greeted the second peg board test with seeming pleasure, and some would have started to put the pegs in before the directions were completed if they had been permitted.

The board was so placed with reference to the child that the blue stripe came to the right, the orange in the center, and the green to the left. The stripes ran at right angles to the front

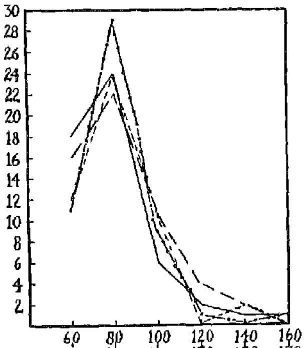


FIG. 2. RELATIVE TIME SCORES. COLORED PEG BOARD

——— Mexican; – —— Italian; — — — -- S. D. American; —●—●— Baltimore American.

edge of the table. The pan of pegs was placed at the right of the board unless the child were left-handed, then both pan and board were reversed.

The pegs were thoroughly mixed in the pan so the colors had to be picked out. This may have been a reason why the test took a longer time than the plain peg board, for in the latter test the children who made the best time did not look back at the pan of pegs each time, but picked up a peg without looking. In the case of the colors, the peg had to be selected each time, and, when it came to the last two or three of a color, the child would perhaps have to hunt for them. The pan is which the pegs were kept was large enough for all the pegs to lie flat without covering each other if they had been placed in order, but this was not the procedure.

In over two hundred children tested, not a single child appeared to be color-blind, at least as far as these 3 colors (blue, yellow, green) were concerned. If by chance a child put a peg in the wrong stripe he either changed it immediately or when he found a peg left over of the color he was filling. One child discovered that she had put a blue peg in the green space and said "Do you know why I got the blue one in there? Because my eyes are bad."

The majority of the children selected one color and filled all openings there first, then took another color. But in this, as in the plain peg board test, every variety of procedure was used. One child put one row of each color in first; then filled in the second rows in the same order. Some began with the blue and put in rows front to back and back to front uniformly all the way across, ending with the green pegs. Only one child put *into* the appropriate stripe whatever peg he happened to pick up without looking. About half of the children filled in the green stripe first, though some of them filled the blue second and yellow last.

There were still quite a number who found it difficult to refrain from picking up more than one peg at a time.

The control of the left hand, as far as its reaching over to help the right hand was concerned, was much improved in this test, though it showed much the same activity or relaxation that it showed in the first peg board test.

The average time in performing this Colored Peg Board test was slightly higher than the time for the Plain Peg Board test. Table 4 shows these differences.

With some children the left hand would leave the corner of the board and be dramatically held out to the side with the fingers spread. Never was that particular manner of holding the left hand observed with the American children. This may have been chance but it seemed worth noting. In a number of cases of both American and foreign children the left hand left the board to grasp the dress tightly, or, in 2 cases to be held against the stomach or with the fingers spread apart. Sometimes the left hand was taken from the corner of the board and the edge of the table grasped. Some of the children held the index finger only on the corner of the board. In several cases the child started to take a handful of pegs in the left hand to feed the right hand. In many cases, more especially among the American children, the left hand would either be held in a relaxed position in the corner of the board or the child would drop it by his side. It was notable that the more tense positions were shown when the child appeared conscious of trying to go fast.

TYING A BOW-KNOT

In the Stanford Revision of the Binet-Simon tests, Terman places the tying of a bow in the seventh year, but in this study it was used for all three ages represented. The procedure differed in 2 points from that given by Terman: first, the term "bow-knot," was changed to "bow" as the word *knot* confused the foreign children. The second point of difference was that the bow-knot was not tied around my finger, as with very young children where there is any shyness to be overcome, it has been my experience that one gets better results if the personal element is entirely eliminated, so a stick was substituted with the model on the same stick.

There is also a time element in the procedure of tying around the finger, the child may feel more hurried than when tying around a stick. The directions were "See, here is a bow; I want you to take this string and make the same kind of a bow on this stick." The criticism made by Terman that the stick often fell out of the string was not true of the test in this study. The stick was large enough (8 inches long and 1 inch wide) so the child kept it down on the table while he worked.

Table 5 shows the distribution. Of seven-year-old Mexicans none failed; of the 19 seven-year-old Sicilians 4 failed; of the 3 seven-year-old San Diego Americans 2 failed; and of the 15 seven-year-old Baltimore Americans 3 failed. The Mexicans show the lowest percentage of failures.

Considering the fact that the Baltimore American children were taught to tie their shoe-strings when they entered the kindergarten and the other 3 groups were not, it seems that the Baltimore Americans showed a high percentage of failures. There were several types of failure in this test;

some had no idea at all about any procedure to accomplish the task, others made the first loop, put the other string around it but when it came to pulling through the second loop they put it through the first loop instead of the wrapped around string. Others laid out 2 loops, 1 for each string-end, then picked up the loops and tied in a knot. This made a two-loop bow that would not pull loose easily but was not like the model.

failures in each group with the San Diego American group, (this is the group used in the correlations), the group making the least number of failures is the trained Baltimore American group. The Mexican percentages are lower for the six and seven-year-olds than the San Diego Americans, but higher in the six-year-old group but the aggregate of percentages is much lower for the Mexicans. The same data are found in the comparison

TABLE 5

Distribution of failures in tying a bow-knot

	5 YEARS				6 YEARS				7 YEARS				TOTALS			
	Mexicans	Sicilians	San Diego Americans	Baltimore Americans	Mexicans	Sicilians	San Diego Americans	Baltimore Americans	Mexicans	Sicilians	San Diego Americans	Baltimore Americans	Mexicans	Sicilians	San Diego Americans	Baltimore Americans
Number of boys	4	3	10	7	11	11	10	13	3	10	2	6	18	24	22	26
Number of girls	17	8	18	7	14	14	9	10	4	9	1	9	35	31	28	26
Boys—failures	2	2	8	2	0	8	4	2	0	2	2	1	2	12	14	5
Girls—failures	8	3	7	1	1	4	1	5	0	2	0	2	9	9	8	8
Totals	10	5	15	3	1	12	5	7	0	4	2	3	11	21	22	13
Percentage of failures	.47	.45	.53	.21	.40	.48	.26	.30	0	.21	.66	.20	.20	.38	.44	.25

When the children failed and were asked, "Don't you tie your own shoe-strings?" the child's invariable reply was "My mother does it." Johnson (6) states that "It was observed that the Italian children who failed almost universally in tying a bow-knot, wore button shoes and upon inquiry it was ascertained that these children rarely wore shoes with laces." In observing the groups used for this study, some of the failures were made by children wearing button shoes but by no means was this universally true.

In comparing the percentage of of the Sicilian group with the San Diego American group, as for the Mexican and San Diego American. In comparing the Mexican and Sicilian groups, the five-year-olds of the Mexican group show a slightly higher percentage of failures, but the six-year-old group is lower and the seven-year-old group of Mexicans has no failures at all while the Sicilian group has .21 per cent of failures.

In the test of the tying of a bow the Mexican group rates higher than any but the Baltimore American group.

SEGUIN-GODDARD FORM-BOARD

The fourth test was the Seguin-Goddard Form-Board, which is too well known to require a description here; suffice it to say the standard form-board was used. The procedure with these young children was to place the 3 piles of forms to the right of the board and not at the back, because the latter presented some difficulties in reaching for the small children. The directions were: "See how fast you can put these blocks back in the holes where they belong. Ready, go!" The time was kept with a stop-watch. There were 3 trials on this test, the shortest time of the three was taken as the score.

The average time and median for each group was as follows:

The above average scores show that in this test the Mexican group made the shortest time of any of the groups; the longest time being scored by the Sicilian group.

Goddard form-board

	AVERAGE TIME	MEDIAN
	seconds	
Mexicans:		
Boys	29	28
Girls	29	
Sicilians:		
Boys	42	41
Girls	48	
San Diego Americans:		
Boys	31	31
Girls	36	
Baltimore Americans:		
Boys	40	40
Girls	45	

There was no difficulty in securing coöperation on 3 trials, for the children were sent to me "to play games," and they took this repetition as part of the game. At the end of the first trial I said: "We do this 3 times to see if we can do it faster each time." In some cases the shortest time was made on the first trial, but in many of the cases on the second trial. At times it would seem, in observing the performance in this test, as if the last trial was going to prove much shorter, then perhaps the child would fumble in putting in the star or cross, or would

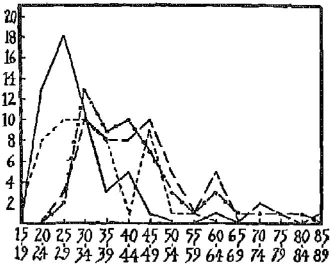


FIG. 3. RELATIVE TIME SCORES. GODDARD FORM BOARD

——— Mexican; —— —— Italian; — — — — S. D. American; —o—o— Baltimore American.

hesitate over the placing of some form that had gone in with no hesitation in the other 2 trials, and instead of making a shorter time, he would take longer for this trial than for either of the other two. There was one performance that occurred in a number of cases; the child would put the blocks in place in the first trial with practically no hesitation nor "hovering," but on the second trial would begin to hesitate and hold the block hoveringly above the board before

finding its place. Sometimes this response was even more pronounced in the third trial than in the second. Yet all the time such a child had the appearance of greater interest even than in the first trial.

Sometimes a child would drop a block on the board, or lay it to one side on the board, if he did not at once recognize the place for it. Then it would be placed when he recognized its proper place or would be left there to be put in place after all the others were in. Many of the children attempted to put the forms into the wrong places. Most of these mistakes occurred in forms of similar shapes; for example, the ellipse in the circle, or the diamond in the hexagonal space or vice-versa. There were some who tried to fit into the openings shapes that were dissimilar, such as the triangle in the circle and square in the diamond. A few started out with a trial and error method, giving no attention to the shapes but merely trying the blocks in the different openings until they found the right one. This method was not employed after the first trial in any of these cases.

The first performance was often very different from the other performances and offered a much more interesting study, as to the time element as well as the form perception and quality of attention shown.

Left hand

In this test the children were given no instructions concerning the use of the right or left hand, so in some cases the child used the left hand as much as the right hand, after the blocks were picked up by the right hand. In only 2 cases was it noted that the child reached to pick up the blocks with the left hand. The left hand was sometimes used to hold a block for which the proper place was not immediately recognized, and when the place for it was recognized this block would be put in with the left hand.

SCREWING NUTS ON BOLTS

The fifth test was screwing nuts on 6 bolts. The bolts were $4\frac{1}{2}$ inches long and $\frac{1}{2}$ inch in diameter with square head and square nut. They were threaded at one end $1\frac{1}{4}$ inches on the shaft. The nuts were $\frac{3}{4}$ of an inch square and $\frac{3}{8}$ of an inch thick and had been cleaned and slightly oiled when they were new, so the nuts would run on freely. The bolts were laid in a row, the head end toward the child; the nuts were in a row, one at the thread end of each bolt.

The directions were: "I want to see how fast you can put all these nuts on these bolts, running the nuts on as far as they will go, like this." I took up a bolt and, holding it in my left hand, started the nut and then ran it on as fast as possible with the fingers of my right hand, put it down quickly and started to pick up another without actually doing it. The children seemed anxious to do this test and, unless restrained would have started to carry out the directions before I put the bolt back. As soon as bolt and nut were in place, I said, "All right, ready, go!", starting the stop-watch as soon as bolt and nut were in the hands of the child.

There was one feature in this test affecting the amount of time the test took that was true in nearly every case.

If a right-handed child kept the bolt in his right hand and put the nut on with his left hand, almost without exception, the time for completing the task was longer, in some cases very much longer than when the nut was in the right hand and bolt in the left. In the first method the child was apt to experience great difficulty in getting the nut started, for he would screw it the wrong way and sometimes drop it off three and four times; sometimes it would drop to the floor. Some children would suddenly realize what the difficulty was and shift the bolt to the other hand. If they did not do this they were obliged to screw the nut toward them instead of away from them. Some children tried to run the bolt on against the palm of the left hand, but for the most part they laboriously turned the nut on little by little. Some of the children shifted the position of nut and bolt in the hands several times during the test.

A number of the children would hold the bolt upright on the table, balance the nut on top, then run it on with the right hand. The children employed a surprising number of different methods of procedure in performing this task. Some were very particular, in putting the assembled bolt and nut down, to lay it straight on the table and line the next ones up with it. Those who were quickest in the test were the ones who held the bolt in the left hand and ran the nut on either with the palm or fingers of the right hand, or very often with only the first finger of the right hand.

Twice one child changed the direction of the turning of the nut and nearly screwed off 2 nuts before he realized the fact. Then, in changing from a method of slowly turning the nut on, the children would try to run it on in the palm of the hand and would turn the nut off instead of on. Some of the children chattered all the time until urged to hurry. A number of children who had difficulty getting the nut started would change the nut for another. One boy said, "Gosh, this one sticks, I guess it isn't the right one." It was observable that most of the children who had any difficulty in getting the nut started would show a reaction of the mouth, either it would be open, or the tongue would come out, or be twisted. Whenever there was difficulty starting, the children almost universally tried to force the nut on, some pushing as hard as possible with the nut quite crooked on the end of the bolt.

Very few of the children retained the idea of the necessity for speed; once in a while a child would appear to try to "go as fast as he could," but in only 2 cases was this attitude maintained throughout the performance. The comments of the boys on seeing the bolts were; "My father has some bolts like those." "We got some of these in our machine." "I can do that." "Gee! that's easy!" "I have these in my tricycle." The comments of the girls were of quite a different character; "None of the kids can do things as fast as me." "Hard to do, ain't they?" "Come on here, you old nut!"

The shortest time-score for this test was 44 seconds, made by a San Diego American girl; the longest time was taken by a Sicilian child who took 5 minutes 40 seconds for the test.

The average time for the test is as follows:

	AVERAGE TIME	MEDIAN
	seconds	
Mexicans:		
Boys	107	112
Girls	141	
Sicilians:		
Boys	118	125
Girls	191	
Baltimore Americans:		
Boys	119	130
Girls	149	
San Diego Americans:		
Boys	166	120
Girls	157	

The only group in which the girls' average was lower than that of the boys was the San Diego American group. In this test the average for the Mexican boys was lower than the boys of any other group and the average of the Mexican girls lower than the girls of any other group.

BUTTONING A BELT IN THE BACK

This was the sixth test and offered a very interesting set of reactions for study. The belt was 2 inches wide and 34½ inches long, made of plain blue calico, with a button ⅝ of an inch in diameter sewed on one end with strong linen thread in such a way as to leave a shank of ⅛ of an inch. A buttonhole was on the other end of the belt, $\frac{13}{16}$ of an inch long, through which the button passed with ease. When a child was given this test the belt was adjusted to his waist size by taking a plait in the middle and pinning with a safety pin.

The directions were: "Hold this belt out in front of you like this (illustrating the button end in the left hand and buttonhole in the right), and when I say, 'Ready, go!' I want you to put it around you and button it in the back as quickly as possible," (illustrating the action of putting it around the waist without buttoning). The belt was handed to the child with the button end in the left hand and buttonhole in the right, and the directions given.

Although, before starting the tests, the children had the explanation given them that nearly all the tests were timed "with this watch to see how fast you can do them," and in spite of the fact that this method of direction had been given for previous tests, 3 of the children, in taking this test, started to run across the room at the word "Go!" However, all the others followed the directions. If a boy had on a heavy sweater it was taken off; or if a little girl's dress were full and loose, a plait was pinned over in the front so that it would not get in the way.

Three trials were given and the shortest time-record for the three taken as the score.

The average time for each group was as follows:

	AVERAGE TIME	MEDIAN
	seconds	
Mexicans:		
Boys	6	5
Girls	9	
Sicilians:		
Boys	7	7
Girls	7	
Baltimore Americans:		
Boys	8	7.5
Girls	7	
San Diego Americans:		
Boys	11	7
Girls	8	

The Mexican boys show the shortest time record, but in the aggregate of records for both boys and girls the Sicilians are the lowest and San Diego Americans, the highest.

Some of the children buttoned the belt easily in 2 seconds, but others took a long time. One Mexican child took a minute on one trial.

The action of the hands in this test was very interesting. The child who had the shortest time records put his first finger through the buttonhole and the button in thumb and finger of the left hand when he held the belt out in front. The time scores for the 3 attempts were many times very wide apart. Sometimes the poorest score would be the last attempt. Very often the shortest score was the first or middle score. When a child was having difficulty in getting the belt buttoned, he would often open his mouth, run out his tongue or shut his mouth tight or twist his leg or foot around, nearly losing his balance. Some grunted and said, "Gee, this is hard."

The Baltimore American group and the Mexican group had the longest and the shortest time-scores. The shortest time was 2 seconds.

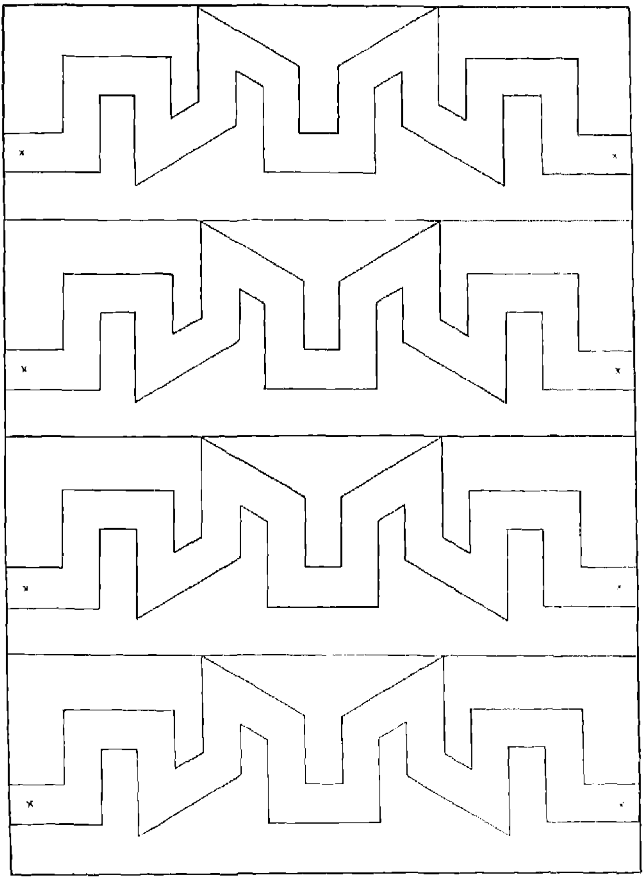
THREADING NEEDLES

The only tests in this series of eleven, requiring fairly fine motor coördinations were the threading of needles and the drawing of lines within a certain path without touching the sides of the path.

Certainly both of these tests offer very interesting study material for steadiness of hand which might form a basis, in the writer's estimation, for the study of the neural condition of the child, his general body-vigor, perhaps of his temperamental reactions also.

The 6 needles used in this test were the long-eyed needles used for wool embroidery and were number 1; the thread was linen, number 25. The threads were cut about 8 inches long and were waxed at both ends; they were re-waxed for each child and a new set of threads was cut each day, so each set was used by only 4 or 5 children.

The needles were stuck in a small cushion, and the thread laid in a row on the table in front of the child. The directions were: "Here are 6 needles and 6 threads; the threads are waxed at both ends, so they will go into the needles easily. If you spoil one end of the thread you can turn it around and use the other end. I want to see how quickly you can thread all these needles with these threads, like this." (I illustrated by threading a needle and dropping it on the table, then picked up another needle but did not thread it.) Replacing the needles and thread, I said, "Ready, go!" A stop-watch recorded the time. The length of time taken by the children in this test depended largely upon steadiness of hands, but one other element affecting the time-score was whether the needle was held in the left hand and the thread in the right or the reverse. When the needle was held in the right hand the scores show that the performance took a longer time in most instances. The left hand showed a greater amount of unsteadiness, and would sometimes give little jerks. The only exception to this observed condition was when the thread was held stationary in the left hand



Johnson Coördination Test

while the needle was put on it. This method took a shorter time than when the child tried to put the thread through the eye of the needle with the left hand. When the needle was held in the left hand and the thread put through with the right, in most instances the time-record was shorter. Some of the children had very unsteady hands, sometimes a continuous tremor was noticeable and sometimes the hands would jerk. This was a test in which the left hand certainly showed poorer motor coördination than the right.

In some cases the child would fail to see that the center part of the long eye had a wider opening than the top or bottom, and would make many futile

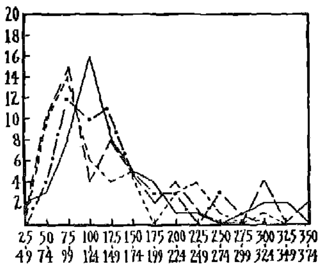


FIG. 4. RELATIVE TIME SCORES. THREADING NEEDLES

———Mexican; —— —— Italian; — — — — S. D. American; —●—●— Baltimore American.

attempts to put the thread through where the opening was too small. The time was also prolonged when the child would split or bend one end of the thread and had to turn the thread around and use the other end.

The shortest time taken for this test was 29 seconds, found in the San Diego American group: in this group is also found the longest time-record, 450 seconds.

The medians for this test appear rather high. In the averages the San Diego American group makes the best record:

	AVERAGE TIME	MEDIAN
	seconds	
San Diego Americans:		
Boys	118	100
Girls	144	
Sicilians:		
Boys	118	110
Girls	155	
Mexicans:		
Boys	138	114
Girls	139	
Baltimore Americans:		
Boys	145	125
Girls	125	

MOTOR COÖRDINATION

Another coördination test was given using the blanks of the Hopkins series of coördination tests. Since they are not numbered, a blank is inserted in this test to show the size of the design. The instructions were: "I want you to draw a line in the middle of this path as fast as you can go from this point to this point. Take your pencil this way and keep your arm up from the paper." (I illustrated the method by holding my pencil vertically and drawing an imaginary line in the path all the way across.) After this method of instruction no other difficulties were encountered except in the position of holding the pencil, in order to keep the hand up from the table. This position was well maintained if the

child were watched and reminded to hold his hand up in case he forgot.

When the child's hand was in position, the signal was given "Ready, go!" The time was kept with a stop-watch.

Some of the children went slowly in order to keep in the middle of the path, others, perhaps keeping the time element in mind, went fast. Some drew the line lightly and showed very poor coördination, others whose hands appeared just as unsteady bore down heavily on the pencil giving a very steady, firm looking result. There were some who dashed along the path letting the line strike the sides again and again. When this happened in the first response, and it appeared that he had not really understood the import of the instructions, "in the middle of the path," was repeated.

The time varied from a record of 6 seconds for a line, up to 21 or 22 seconds.

The score was the sum of all the contacts with the sides of the path found in the 4 designs on the blank. The contacts recorded were from 0 to 37, and the averages were as follows:

	AVERAGE CONTACTS	MEDIAN
Baltimore Americans:		
Boys	6	6
Girls	8	
Mexicans:		
Boys	9	7
Girls	6	
San Diego Americans:		
Boys	9	8
Girls	9	
Sicilians:		
Boys	11	9
Girls	9	

Left hand

It was very noticeable that when the children were making a great effort to draw a steady line in the path, the left hand would press down heavily on the paper. Sometimes when the tension was great, in trying to draw the line quickly, the child would hold his left hand in a fist on the paper.

STRING BUTTONS

The last test given in this series was the stringing of 36 wooden button-

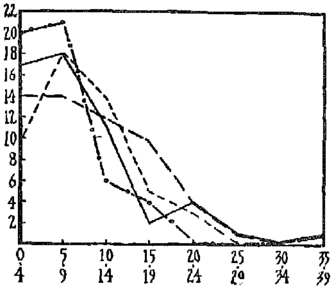


FIG. 5. RELATIVE NUMBER OF CONTACTS. MOTOR COÖRDINATION

——— Mexican; —— —— Italian; — — — — S. D. American; —●—●— Baltimore American.

molds on a round shoestring. The button-molds were circular, flat on one side and convex on the other, with a hole in the center $\frac{1}{8}$ inch in diameter, so the button slipped easily on the string. The string had a knot at one end and a tin tip at the other.

The buttons were placed in a shallow pan. The child was given the tip-end of the string and the directions were: "See how fast you can string all these

buttons on this string picking up only one at a time. Ready, go!"

The children who had been in the kindergarten were very familiar with this performance and that fact doubtless had some effect upon the scores obtained. Many seemed to take the attitude of settling back and taking it easy. A number of the children chattered about home, brothers and sisters and other things until reminded to hurry. There were many others, however, who kept up the spirit of playing a game until the end, and these children made the best time-scores.

The children used many different methods of accomplishing this task. Some of the children took the string in the right hand and put the buttons on with the left hand, and others reversed this process. Some kept the bunch of strung buttons on the table and drew the string through each time as if sewing with a very long thread.

There were those who let the bunch of strung buttons lie on the floor, and as they strung the single buttons on would let those buttons drop to the floor without giving them any further attention; others would shove each button all the way down the string until it reached those already strung.

Sometimes the entire time would be lengthened by the fact that the string was held in the right hand and the bunch of buttons stung dropped to the floor on the opposite side, so the button had to be shoved down the string each time. Only a few of the children let the buttons fall wherever they chanced to, without giving them further thought. There was one method that lengthened what otherwise would have been a short-time score. The arrangement of string and bunch of buttons would be good, the child would let the buttons drop down the string giving them no more attention, once they were on the string, but every few seconds he would hold up the bunch of strung buttons for one to admire, with the remark; "See what a lot I have strung," or "It looks like a big worm." It was noticeable throughout the 3 nationalities, that

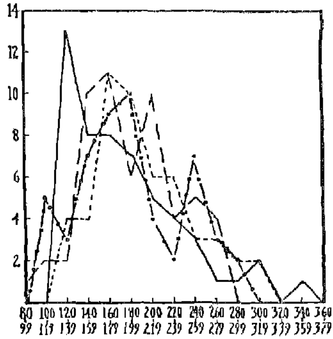


FIG. 6. RELATIVE TIME SCORES. STRINGING BUTTONS

— —— Mexican; —— —— Italian; — — — — — S. D. American; —o—o— Baltimore American.

most of the children put the string through the button from the flat side, few of the children had a hit or miss arrangement on this particular point. Three children strung first from the convex side then from the flat side giving an entirely different appearance to the finished product. One of these children would remove a button and string from the reverse side if he chanced to put one on wrong. These

children's records were among the long-time ones.

There were a goodly number of children who retained the idea of its being a timed test throughout, and who started out with the string in the left hand, the knotted end on the floor to the left, and who put the buttons on the string rapidly with the right hand letting them drop where-ever they happened to. These were the children who made the shortest time-records.

The shortest time was made by a Sicilian child, 98 seconds; the longest time-record by a Sicilian child also, 386 seconds.

The averages are as follows:

	AVERAGE TIME	MEDIAN
	seconds	
Mexicans:		
Boys	190	169
Girls	184	
Baltimore Americans:		
Boys	191	185
Girls	188	
Sicilians:		
Boys	195	187
Girls	191	
San Diego Americans:		
Boys	206	197
Girls	199	

The above averages show that the Mexican children made a slightly better record than the children of the other groups.

SUMMARY

A comparative study of racial differences in manual dexterity has been made for Sicilian, Mexican, and native American children, the criterion of race being the birthplace of their parents. There were 2 groups of American children, one from the Atlantic coast and of favored social status, the other from the Pacific coast and of approximately same economic level as the Mexicans.

There were 212 children between the ages of four and seven tested, almost evenly distributed among the race groups. The sex differences within the groups were not so well equated.

Two forms of tests were given for obtaining an approximation of the mental level of the children in relation to standards for children of these ages. The scores for the Goodenough Drawing Test gave intelligence quotients that ranged from 70–170; these quotients were above the norm or 100 for 77 per cent of the Mexicans; 60 per cent of the Eastern Americans; 58 per cent of the Sicilians; 56 per cent of the Western Americans. For the Picture Puzzle series there are no norms. The scores compare favorably with the similar Rossolimo series and show that the group as a whole do as well as a larger group of American children. The Mexicans showed superiority in this test.

There were 8 performances in which manual dexterity played an important part. The Mexicans ranked highest in four of these tests and tied for superiority in another test. Their average rank on the series was 1.7; Baltimore Americans 2.3; Sicilians and San Diego Americans 2.8 each. For these groups the Mexicans are clearly superior in the quickness and accuracy of manipulation such as the tests involved. The conclusion can not be drawn for Latin races and not

for races in general. It does appear that certain racial groups or stocks develop early skill in manipulation greater than that of the average of American children. A control of the environments from the first months might throw light on the origin of such differences.

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An Experimental Investigation of Young Children's Interest and Expressive Behavior Responses to Single Statement, Verbal Repetition, and Ideational Repetition of Content in Animal Stories

Lois Z. Smith[1]

THE aim of this study was to develop an experimental technique for measuring and comparing the interest and expressive behavior responses which two-, three-, and four-year-old children give to single statement, verbal repetition, and ideational repetition of content in animal stories.

The study involved (1) the writing of stories containing these three elements, (2) the training of observers and the establishing of reliability in the use of the observer's blanks, and (3) conducting the experimental story groups.

The subjects used in the establishing of the reliability of the observers were 14 four- and five-year-old children who were attending the preschool laboratories of the Iowa Child Welfare Research Station. The subjects of the experimental story groups were 33 two-, three-, and four-year-old children. The average chronological age of the group used for establishing the reliability of the observers was 42.5 months with a standard deviation of 7.21 the average mental age 50.0 months with a standard deviation of 8.87. The average chronological age of 27 children in the main experimental group given the Stanford revision of the Binet scale was 50.9 months with a standard deviation of 6.25, and an average mental age of 59.3 with a standard deviation of 9.96. The 6 children given the Kuhlmann revision of the Binet scale had an average chronological age of 36 months with a standard deviation of 2.52 and an average mental age of 43.2 with a standard deviation of 5.46.

PREPARATION OF THE STORIES

The stories for the experiment were written so that they would contain certain general characteristics recommended by educators and writers of young children's stories. The follow-

[1] This study was directed at the Iowa Child Welfare Research Station by Dr. Esther Van Cleave Berne. The detailed report is given in an unpublished Master's Thesis, University of Iowa, 1929. Pp. 169.

guiding principles in
f the stories:

ıt told in chronological
to be used as a plot.
› be within the child's

› must be understand-
·en.
her words, phrases, or
st be simple.
ı are fond of animal
ch the animals talk and
.

ıs borrowed from a
ildren. It supplied
onological sequence
he experience of the
e story *Two Little*
from a story called
ers (10). The story
se who had lost her
sequence of events
ttempt to find them.
original story were
e experimental story
ts were re-written.
stories used in the
Little Kittens and
were suggested by
How Spot Found a
ıell's *Here and Now*

ıoosing a vocabulary
ich children of these
erstand, all of the
ory were listed and
n children's vocabu-
The studies of Bate-
(3, 4), Brandenburg
d Gale and Gale (7)
se studies were used
in constructing her
for young children.
s which occurred in

five or more of the vocabularies were used.

In order to make the story simple, short declarative sentences were used as often as possible. The average number of words in the sentences used in the stories was six.

The stories were written in 3 forms. Form A was told in single statements. The 2 similar characters were treated as a unit by means of a plural or compound subject. For example:

> "Mr. Goose and Mrs. Goose had lost their rubbers.
> They said, 'We must have them to go down town.'"

Form B was told with a verbal repetition of content. In this form each of 2 animal characters responded individually. The words used to describe the behavior of the first character were repeated in describing the behavior of the second except that the pronouns were varied in sex and number to agree with their respective antecedents and the verbs were changed in form to agree in number with their respective subjects. For example:

> "Mr. Goose had lost his rubbers.
> He said, 'I must have them to go down town.'
> Mrs. Goose had lost her rubbers.
> She said, 'I must have them to go down town.'"

In Form C the stories were characterized by ideational repetition. Each one of the two similar characters responded individually. The first character acted and spoke. The same words were used to describe this action as those used in Form A and in Form B in the repeated statements about both characters. In describing

the behavior of the second character in Form C the idea is repeated but the words are different. For example:

"Mr. Goose had lost his rubbers.

He said, 'I must have them to go down town.'

Mrs. Goose's rubbers were lost. 'I cannot go to the store without them,' she said."

From observation of story groups in the preschool laboratories it was decided that a story requiring three minutes would come well within the period during which even the youngest child could give attention to the story. The reading of Form A required $1\frac{1}{2}$ minutes, and Form B and Form C each required 3 minutes. The stories were written in one-half minute units so that each item of expressive behavior or interest could be checked on the basis of occurrence within half minutes. Each unit of a story was typed in the story book on the space between two leaves so that turning a page indicated to the observers the end of a half minute unit.

Three comparable stories were written for the experiment, one for use as a trial story in establishing reliability; the others for use in the experiment proper. The story *Two Little Geese* is reported on page 235.

TRAINING OF THE STORY-TELLER

The story-teller made special preparation for the telling of the stories in order that the telling would be as uniform as possible. Each form of each story was memorized. A careful study was made of the enunciation, pronunciation, expression, and voice used in telling the stories. The story was timed so that the story-teller always took the same amount of time in telling it. Persons trained in telling children's stories criticized the story-teller's presentation of the story. A small story book which lay on the lap of the story-teller served as a guide and aided in maintaining uniformity.

The personality of the story-teller as manifested by dramatic pause, voice quality, inflection, and facial expression was evidenced only enough to insure the children's interest and was made uniform for all forms of stories.

At the end of the experiment the story-teller asked the observers to report on her uniformity in manner and time of presentation of the stories. The following reports were given:

OBSERVER X	OBSERVER Y	OBSERVER Z
Time		
Very uniform for each form	Seemed to be the same for the forms that were alike	Uniform
Presentation		
Differed very little	Surprisingly uniform	Uniform. Fatigue may have made a little difference in last of the six stories given in one day

TRAINING THE OBSERVERS AND ESTABLISHING THE RELIABILITY OF THE OBSERVER'S BLANK

Following the preparation of the stories, the next problem was the development of a technique for recording the interest and expressive behavior of the children in the story

TWO LITTLE GEESE

FORM A	FORM B	FORM C
Mr. and Mrs. Goose could not find their red rubbers. "We need them to go down *town*," *they said*. They had pecked into every corner of the little dark closet under the stairs. Their red rubbers were not there. Mr. and Mrs. Goose looked under the bed. They opened the ice box and looked into it. Their red rubbers were lost.	Mr. Goose could not find his red rubbers. "I need them to go down *town*," *he said*. Mrs. Goose could not find her red rubbers. "I need them to go down town," she said. Mr. Goose peeked into every corner of the little dark closet under the stairs. His red rubbers were not there. Mrs. Goose peeked into every corner of the little dark closet under the stairs. Her red rubbers were not there.	Mr. Goose could not find his red rubbers. He said, "I need them to go *down town*." Mrs. Goose's rubbers were lost. She said, "I cannot go to the store without them." Mr. Goose peeked into every corner of the little dark closet under the stairs. His red rubbers were not there. From top to bottom of the dark closet Mrs. Goose looked for her red rubbers. She did not find them.
Mr. and Mrs. Goose rolled up the rug and looked under it. They saw no red rubbers. They heard the rain drops hitting the roof of their house. They put on their coats and hats. They picked up their baskets and very green umbrellas. They went out the door. Mr. and Mrs. Goose closed the door.	Mr. Goose looked under the bed. Mrs. Goose looked under the bed. Mr. Goose opened the ice box and looked into it. His red rubbers were lost. Mrs. Goose opened the ice box and looked into it. Her red rubbers were lost.	Mr. Goose looked under the bed. Down under the bed Mrs. Goose crawled to look. Mr. Goose opened the ice box and looked into it. His red rubbers were lost. Mrs. Goose could not find her rubbers in the ice box. They were gone.
They opened their big green umbrellas. Plop! Four big somethings fell on their heads nearly knocking their hats off. Mr. and Mrs. Goose looked to see what had dropped. There were their red rubbers. They put on their red rubbers. They walked in the water on their way down town.	Mr. Goose rolled up the rug and looked under it. He saw no red rubbers. Mrs. Goose rolled up the rug and looked under it. She saw no red rubbers. Mr. Goose heard the rain drops hitting the roof of the house. Mrs. Goose heard the rain drops hitting the roof of the house.	Mr. Goose rolled up the rug and looked under it. He saw no red rubbers. Mrs. Goose's red rubbers were not under the rug. She lifted it to look. Mr. Goose heard the rain drops hitting the roof of his house. The rain was falling on the top of the house. Mrs. Goose listened.

TWO LITTLE GEESE—*Concluded*

FORM A	FORM B	FORM C
	Mr. Goose put on his coat and hat. Mrs. Goose put on her coat and hat. Mr. Goose picked up his basket and green umbrella. Mrs. Goose picked up her basket and green umbrella. Mr. Goose went out on the porch. Mr. Goose closed the door. Mrs. Goose went out on the porch. Mrs. Goose closed the door.	Mr. Goose put on his coat and hat. Mrs. Goose had her wraps on. Mr. Goose picked up his basket and green umbrella. Mrs. Goose was carrying her basket and green umbrella. Mr. Goose went out on the porch. Mr. Goose closed the door. Mrs. Goose shut the door behind her.
	Mr. Goose opened his big green umbrella. Plop! Two big somethings fell on his head. They nearly knocked his hat off. Mrs. Goose opened her big green umbrella. Plop! Two big somethings fell on her head. They nearly knocked her hat off. Mr. Goose looked to see what had dropped. There were his little red rubbers.	Mr. Goose opened his big green umbrella. Plop! Two big somethings fell on his head. They nearly knocked his hat off. Mrs. Goose put up her umbrella. Out of it dropped something that put her bonnet over one of her eyes. Mr. Goose looked to see what had dropped. There were his little red rubbers.
	Mrs. Goose looked to see what had dropped. There were her little red rubbers. Mr. Goose put on his red rubbers. He walked through the water on his way down town. Mrs. Goose put on her red rubbers. She walked through the water on her way down town.	Mrs. Goose saw that her two little red rubbers had fallen out of her umbrella. Mr. Goose put on his red rubbers. He walked in the water on his way down town. With her red rubbers on her little feet, Mrs. Goose went through the rain to the store.

situations. The observer's blank as used in this study lists 5 types of expressive behavior (1) laughs, (2) smiles, (3) claps hands, nods approval, etc. (4) annoyed, (5) neutral; and 3 types of interest (1) watches, (2) any combination of watching or not watching, (3) does not watch.

The experimenter in weighing the observations of expressive behavior assumed that greater amounts of expressiveness in enjoyment or disapproval of the story should be given the higher positive or negative scores while less expressiveness should be given scores falling between the extremes. Thus the scale of expressive behavior ranges from −1 to 3 with 1 as the midpoint for neutral expressiveness.

Expressive Behavior Items	*Score*
1. Laughs—the child's amusement is expressed by a chuckle, giggle, or snort..................	3
2. Smiles—the child's mouth is drawn up into a smile..........	3
3. Claps hands, or nods approval...	3
4. Annoyed—the child scowls or watches the door.............	2
5. There is an absence of 1, 2, 3, and 4. The child has a neutral expression....................	1

A scale for interest values was chosen which ranged from 0 to 2. The score of 1 served as a midpoint from which differences were judged. The following are definitions of interest items:

Interest Items	*Score*
1. Watches—the child's eyes are focused on the story-teller all of the time except possibly for a glance.......................	2
2. Any variation between 1 and 3...	1
3. Does not watch—his eyes are focused on other things—not on the story-teller except for a possible glance...............	0

All three of the observers were college graduates and two were graduate students with special training in child psychology. Twelve hours during a period of two weeks were spent in training the observers for the experiment. This period of training was characterized by the experimenter's telling of stories to groups of children and the observers checking on the observation blank the behavior responses of the same 2 children. Disagreements were noted and discussed. Definitions were agreed upon and examples of the types of behavior cited. This procedure was repeated until the number of disagreements became so few as to indicate that the observers were sufficiently trained.

The agreement of the observers is shown by correlations between observers X, Y, and Z.

RATERS	r	P.E.
Expressive behavior		
X with Y	.98	±.005
Y with Z	.98	±.005
X with Z	.98	±.005
Average......	.98	±.005
Interest		
X with Z	.87	±.027
Y with Z	.95	±.022
X with Y	.99	±.005
Average......	.94	±.017

EXPERIMENTAL STORY GROUPS

The next problem of the study was the division of the two-, three-, and four-year-old children into story groups. Since it was hoped that the influence arising from the individual reactions of the children would be simi-

lar for all the groups, the 6 groups were made fairly comparable on the basis of mental age and extroversion-introversion ratings (8). Thirty-three children served as subjects.

One story was presented to each of the experimental story groups previous to the experiment. This was done for the training of the observers and for the purpose of permitting the children to become accustomed to the experimental story group situation. The story, *Two Little Kittens* was used for establishing reliability, and the stories *Two Little Dogs* and *Two Little Geese* were used in the experiment proper.

The experimental story groups were conducted each week over a period of 6 weeks. The order was arranged so that 3 of the groups received the *Two Little Geese* story first and 3 of the groups the *Two Little Dogs* story first. The forms of each story were presented in 3 different orders so that the influence of position in the series was equalized for each form. The order in which the stories were presented and the record of the actual time taken for the telling of each story are given in table 1.

The first time the child was taken for a story group, the teacher in charge of the preschool group said, "Mrs. . . . . would like to tell you a story." The experimenter said nothing to the children, merely waited for them at the door. The 6 children were brought into the testing room and seated in little chairs grouped around the story-teller. The 3 observers sat facing the children in positions closest to the children whom they were to observe. The story-teller, began by saying, "I am Mrs. . . . . I am going to tell you a story about (giving the name of the story)." She started a stop-watch which she had in the pocket of her smock at the instant she began the story. At the completion of the reading material she had between the pages of the small green-covered story book on her lap, she turned the page. This movement was a signal to the observers that a half minute had elapsed. At the close of the story, the stop-watch was stopped. The experimenter said, "That is all. Perhaps some other day I shall tell you another story." The length of time used in telling the story was recorded and the children were taken back to play.

ANALYSIS OF THE EXPERIMENTAL RESULTS

The interest and expressive behavior scores and the means, standard deviations, and coefficients of variation of the score from Forms A, B, and C of the *Two Little Geese* story and of the *Two Little Dogs* story are shown in tables 2 and 3.

In order to compare the variability of the interest scores and expressive behavior scores from the 3 forms of the 2 stories the coefficients of variation of the scores from the forms were computed in terms of the means and standard deviations of each form. Examination of these percents show that the scores from Form B, characterized by verbal repetition, were less variable than those from the other 2 forms and that scores from Form A, characterized by single statement, were more variable than those from the other 2 forms. The scores from Forms B and C show about equal variability.

TABLE I

Order of presentation and time record of the stories

WEEK	GROUP	STORY	FORM	TIME RECORD OF STORIES	
				minutes	*seconds*
First	I	Two Little Geese	A	1	30
	II	Two Little Geese	B	3	
	III	Two Little Geese	C	3	
	IV	Two Little Dogs	A	1	30
	V	Two Little Dogs	B	3	
	VI	Two Little Dogs	C	3	
Second	I	Two Little Geese	B	3	
	II	Two Little Geese	C	3	
	III	Two Little Geese	A	1	30
	IV	Two Little Dogs	B	3	
	V	Two Little Dogs	C	2	57
	VI	Two Little Dogs	A	1	29
Third	I	Two Little Geese	C	3	
	II	Two Little Geese	A	1	30
	III	Two Little Geese	B	3	
	IV	Two Little Dogs	C	3	
	V	Two Little Dogs	A	1	30
	VI	Two Little Dogs	B	3	
Fourth	I	Two Little Dogs	A	1	32
	II	Two Little Dogs	B	3	2
	III	Two Little Dogs	C	3	
	IV	Two Little Geese	A	1	30
	V	Two Little Geese	B	3	
	VI	Two Little Geese	C	3	2
Fifth	I	Two Little Dogs	B	3	
	II	Two Little Dogs	C	3	
	III	Two Little Dogs	A	1	28
	IV	Two Little Geese	B	3	
	V	Two Little Geese	C	3	
	VI	Two Little Geese	A	1	30
Sixth	I	Two Little Dogs	C	3	
	II	Two Little Dogs	A	1	30
	III	Two Little Dogs	B	3	
	IV	Two Little Geese	C	3	
	V	Two Little Geese	A	1	30
	VI	Two Little Geese	B	3	2

TABLE 2

Interest scores from Forms A, B, and C of the Two Little Geese and the Two Little Dogs stories

CHILD	STORY					
	Two Little Geese			Two Little Dogs		
	Form					
	A	B	C	A	B	C
M469	6	12	10	6	12	10
F320	6	12	10	6	12	10
F415	4	11	6	5	11	8
F427	0	9	4	3	10	5
M401	5	12	5	5	12	8
F483	3	8	0	3	8	6
M468	6	12	10	6	12	10
F362	6	12	10	6	12	10
M419	6	12	10	6	12	10
F477	4	12	8	4	12	8
M431	6	12	7	6	12	7
M272	6	12	10	6	12	10
F473	6	12	7	6	12	7
F391	6	12	9	6	12	9
M450	6	12	9	6	12	9
M494	6	12	9	6	12	9
M474	6	12	9	6	12	9
F498	6	12	12	6	12	12
F401	6	11	12	6	11	12
F306	5	12	10	5	12	10
M370	6	12	10	6	12	10
F380	6	12	10	6	12	10
F463	6	12	12	6	12	12
F471	6	12	10	6	12	10
M263	6	12	12	6	12	12
F485	5	12	10	5	12	10
M475	6	12	12	6	12	12
F389	6	12	12	6	12	12
M355	6	12	9	6	12	9
F351	3	12	12	3	12	12
M279	4	12	12	4	12	12
F369	6	12	11	6	12	11
M464	6	12	11	6	12	11
Mean.....	5.36	11.73	9.39	5.67	11.76	9.76
S.D.......	1.30	.71	2.28	.84	.71	1.95
V.........	24.06	6.05	24.28	14.81	6.04	19.97

In order to discover the consistency of the children's interest and expressive behavior responses to the corresponding forms of the 2 stories, interest and expressive behavior scores from Forms A, B, and C of the *Two Little Dogs* story were correlated with interest and expressive behavior scores

TABLE 3

Expressive behavior scores from Forms A, B, and C of the Two Little Geese and the Two Little Dogs stories

CHILD	STORY					
	Two Little Geese			Two Little Dogs		
	Form					
	A	B	C	A	B	C
M469	6	12	9	6	12	9
F320	6	12	9	6	12	9
F415	5	10	2	5	10	3
F427	1	7	3	4	9	3
M491	5	9	3	6	9	5
F483	2	7	0	4	7	1
M468	3	10	6	3	10	6
F372	3	10	8	3	10	8
M419	3	8	6	3	8	6
F477	5	12	6	5	12	6
M431	5	15	10	5	15	10
M272	3	10	12	3	10	12
F473	9	12	6	9	12	6
F391	3	12	6	3	12	6
M450	3	14	8	3	14	8
M494	3	12	8	3	12	8
M474	3	10	8	3	10	8
F498	3	10	8	3	10	8
F401	3	10	6	3	10	6
F306	5	12	10	5	12	10
M370	10	6	10	10	6	10
F380	7	6	10	7	6	10
F463	3	10	9	3	10	9
F471	3	8	10	3	8	10
M263	3	6	8	3	6	8
M485	3	12	6	3	12	7
M475	3	12	12	3	12	12
F389	5	16	12	5	16	12
M355	7	19	11	7	19	11
F351	5	18	10	5	18	10
M279	5	20	12	5	20	12
F369	3	11	12	3	11	12
M464	3	11	12	3	11	12
Mean	4.21	11.3	8.12	4.48	11.24	8.27
S.D.	1.93	3.46	2.99	1.80	3.37	1.63
V	45.80	30.62	36.82	40.18	29.98	29.71

from Forms A, B, and C of the *Two Little Geese* story.

These correlations were uniformly positive and high, ranging from .96 ±.002 to .99 ±.002, indicating that the agreement between the interest

scores on one form of one story and the same form of the other story was close. Since the correlations between the 2 stories were high, only the results of the 3 forms of the *Two Little Dogs* story were used to determine the amount of agreement among the interest scores of the children from the different forms.

These correlations indicated that between interest scores from the 3 forms there was a positive relationship between Forms A and C (.47 ±.092). The expressive behavior correlations ranging from .28 ±.108 to .32 ±.105 indicated that there was probably no agreement between the expressive behavior scores from stories characterized by single statement, verbal repetition, and ideational repetition of content.

Table 4 gives the means and standard deviations of the interest scores and the expressive behavior scores from Forms A and B, Forms A and C, Forms B and C, arranged for comparison of the different forms of the *Two Little Dogs* story. It should be recalled that the interest and expressive behavior scores from Form A were not directly comparable to the interest and expressive behavior scores of Forms B and C in time since Form A was only one-half the length of Form B or C. For this reason the Form A scores in this comparison were doubled to make them directly comparable. In order to discover whether there were significant differences between the means of the 3 forms the probable errors of the differences between the means and the ratio of the difference between the means and probable errors of the difference were computed.

The mean of the interest scores from Form A was compared with the mean of the interest score from Form C and the results indicated a significant difference in favor of the mean of the interest scores from Form A. The ratio of the difference was 5.24 in favor of Form A. This comparison made on the theory that both stories were 3 minutes in length, indicated that Form A, with a single statement of content, was more interesting than Form C, with ideational repetition of content. A comparison of the interest scores from Form B and Form C shows a true difference between the means; the ratio of the difference between the means to the probable error of the difference being 8.19 indicating that Form B which is characterized by verbal repetition of content was much more interesting than Form C, characterized by ideational repetition of content.

Since it was not known that the length of the three minute story did not decrease the interest or expressive behavior scores from Form B and from Form C, the means of the scores from the first half of Form B and of Form C were compared with Form A. In comparison of the mean of the interest scores from Form A and the mean of the scores from the first 3 half-minute periods of Form B, the ratio of the difference between the means was found to be 4.13. This comparison indicated that the interest in the longer story characterized by verbal repetition, was greater during the first 3 half-minute periods than in the first 3 periods of Form A, characterized by single statement. In a comparison of the mean of the interest scores from Form A and Form C no

significant difference was found; the ratio of the difference being 3.00.

There was a significant difference of 5.66 between the means of the expressive behavior scores from Form B and Form A. The ratio indicating that the expressive behavior of the 33 children in response to Form B with verbal repetition, was significantly greater than that arising from Form A, with its single statement of content. Comparing expressive behavior means of the scores from Form A and Form C for significant differences the ratio of the difference was found to be 1.49. These data show that there was no

TABLE 4

Significant differences between Form A and Form B, Form A and Form C, and Form B and Form C

FORM	MEAN	STANDARD DEVIATION	PROBABLE ERROR	PROBABLE ERROR OF DIFFERENCE	ACTUAL DIFFERENCE OF MEANS	RATIO
			Interest			
A† B	11.34 11.76	1.68 .71	±.196 ±.084	.224	.42	1.88
A B*	5.67 6.00	.84 .00	±.006 ±.000	.083	.33	4.13
A† C	11.34 9.76	1.68 1.95	±.196 ±.229	.301	1.58	5.24
A C*	5.67 5.88	.84 .00	±.002 ±.022	.069	.21	3.00
B C	11.76 9.76	.71 1.95	±.084 ±.229	.244	2.00	8.19
			Expressive behavior			
A† B	8.96 11.24	3.60 3.37	±.422 ±.396	.402	2.28	5.66
A B*	4.48 5.96	1.80 .00	±.103 ±.115	.243	1.48	6.31
A† C	8.96 8.27	3.60 1.63	±.422 ±.192	.463	.69	1.49
A C*	4.48 5.00	1.80 1.95	±.103 ±.143	.173	.52	3.05
B C	11.24 8.27	3.37 1.63	±.396 ±.192	.375	2.97	7.92

* The scores for only the first half of this story were used in the correlation.

† The scores for this story were multiplied by two before correlating.

significant difference between the expressive behavior arising from single statement of content in Form A and ideational repetition of content in form C. Computing the differences between the expressive behavior scores from Form B and Form C, a ratio of the difference of 7.92 was found in favor of Form B. This would indicate that Form B, characterized by verbal repetition, produces greater expressive behavior than Form C, characterized by ideational repetition.

For expressive behavior as for interest, the mean of the scores from Form A were compared with the means of the first half of Forms B and C. Comparison of the mean of the expressive behavior scores from Form A and the mean of the scores from the first 3 half-minute units of Form B gave 6.31 as the ratio of the difference in favor of Form B indicating that the mean of the scores from the first 3 periods of Form B, distinguished by verbal repetition, were significantly higher than the mean of the scores from the 3 time units of Form A, distinguished by single statement of content. In comparing the mean of the scores from Form A with that from the first 3 time units of Form C, the ratio of the difference was 3.05 in favor of the longer story, indicating that the mean of the expressive behavior scores from the first half of the longer story characterized by ideational repetition of content were probably not significantly greater than the mean of the scores from the story characterized by single statement of content.

In order to determine the relation between the interest scores from Forms A, B, and C of the *Two Little Dogs* story and the Marston introversion-extroversion ratings (8) 33 correlations were calculated. These correlations indicated no relationship between interest except with the possibility of expressive behavior on Form A and introversion-extroversion ratings.

The interest scores from Form A, Form B, and Form C and the chronological age of 33 children were correlated. The correlations showed that there was no relationship (.05 ±.117) between age and interest in the story (Form A) characterized by single statement of content and very little relationship (.28 ±.108), between chronological age and interest in the story (Form B) characterized by verbal repetition and chronological age. However, the positive correlation .62±.072, between the interest scores from Form C and chronological age was significant and fairly high indicating that in general the children who were most interested in Form C characterized by ideational repetition, were the older children chronologically.

An insignificant correlation (.17 ± .114) was found between expressive behavior from Form A and chronological age and a low correlation between expressive behavior from Form B (.32 ±.105) and chronological age. The positive correlation of .67 ±.065 between expressive behavior scores from Form C and chronological age was fairly high and significant. These 3 correlations indicated that chronological age was not related to expressive behavior in stories characterized by single statement or verbal repetition of content but that it was related to expressive behavior in stories char-

acterized by ideational repetition of content. In general, as the age of the children increased expressive behavior responses to ideational repetition also increased.

The interest scores from Form A, Form B, and Form C and the Stanford-Binet mental age scores of 27 children were correlated.

According to Fisher[2] a correlation for 27 cases cannot be considered significant unless the ratio of the correlation to its standard error of estimate is at least 2.779. The ratios of the correlations to their standard errors showed no relationship between interest scores arising from single statement, verbal repetition, and ideational repetition of content and mental age; and no relationship between expressive behavior scores arising from Form A, with single statement of content and from Form B, with verbal repetition of content and mental age; however, the partial correlation between expressive behavior scores and mental age, with chronological age constant, approached significance ($r = .381$; $t = 2.019$) while the correlation between expressive behavior and chronological age with mental age constant was not significant ($r = .164$; $t = .940$). The correlation between mental age and chronological age, with expressive behavior constant was .494, t being 2.783. It appears from these correlations that possibly the expressive behavior arising from the ideational repetition of Form C may be related to those factors peculiar to mental age rather than to those factors peculiar to chronological age.

SUMMARY AND CONCLUSIONS

The aim of the present study was to *develop an experimental technique for* measuring and comparing the interest and expressive behavior responses which two-, three-, and four-year-old children derive from single statement, verbal repetition, and ideational repetition of content in animal stories. The solution of the problems arising in the study required 3 procedures; the first of which was the writing of 3 stories containing single statement, verbal repetition, and ideational repetition of content; second, the training of observers and establishing of reliability on the use of the observers blank; third, the conducting of the experimental story groups.

The 3 observers were trained and their reliability was established on the use of an observer's blank.

The subjects of the investigation were 33 children who were enrolled

[2] Fisher, R. A.: Statistical methods for research workers. 2nd. ed. rev. and enl. Edinburgh: Oliver & Boyd, 1928. Pp. xi, 269 (p. 159).

Fisher for small numbers of cases, determines t, the ratio of a correlation to its standard error of estimate, according to the following formula:

$$t = \frac{r}{\sqrt{1 - r^2}} \cdot \sqrt{n' - 2}$$

in which r is the correlation obtained, n' the number of pairs of observations on which the correlation is based and n which equals $n' - 2$ is the number used with t in discovering p, or probability. A table for t reveals with what probability such a correlation should arise, by random sampling, from an uncorrelated population. If the probability is .01, (i.e. one chance in 100) Fisher regards the correlation as significant. The distribution in random samples of partial correlation coefficients is derived from that of total correlation coefficients by deduction from the number of the sample the number of variates eliminated.

in the preschool laboratories of the Iowa Child Welfare Research Station. These subjects were arranged in 6 comparable groups to which the forms of the stories were presented in 3 different orders. The specific findings of this study are:

1. The observation and observer's blank used in this experiment are a reliable technique for the measurement and comparison of the interest and expressive behavior responses of two-, three- and four-year-old children to single statement, verbal repetition, and ideational repetition of content in animal stories. This is revealed by the correlation of $.96 \pm .011$ which is the average of 6 correlations between scores made by the 3 observers on the same children.

2. The coefficients of variability of the interest and expressive behavior scores from all forms of the *Two Little Dogs* story were slightly higher than those from the corresponding forms of the *Two Little Geese* story.

3. The significant differences between the interest of the 33 children in Form A, Form B, and Form C of the *Two Little Dogs* story as shown by the means of their scores seemed to indicate that Forms B, with verbal repetition of content, was more interesting than either Form A with single statement or Form C with ideational repetition of content. The significant differences between the means of scores for expressive behavior showed a significantly greater response to Form B, characterized by verbal repetition of content, than to Form A or Form C.

4. There appeared to be no relationship between chronological age and the children's interest and expressive behavior responses to Form A and Form B. However, there was a positive relationship between Form C, characterized by ideational repetition of content, and chronological age. This meant that the older children were more interested and showed greater expressive responses to Form C of the stories than did the younger children.

5. Although the mental age of the 33 children showed no relationship to the expressive behavior scores made on Form A and Form B of the story, there was a positive relationship between the children's expressive behavior scores from Form C of the story and mental age. This relationship indicated that the mentally older children tended to give the more expressive responses to Form C which was characterized by ideational repetition of content than did the younger children.

6. A partial correlation between expressive behavior scores from Form C and mental age with chronological age held constant approached significance while a correlation between expressive behavior scores from Form C and chronological age with mental age held constant did not approach significance. These correlations indicate that the expressive behavior arising from the ideational repetition in Form C may have been related to those factors peculiar to mental age, and not to those factors peculiar to chronological age.

7. Correlations of the interest scores from the different forms of the *Two Little Dogs* story showed a positive relationship between only Form A, single statement, and Form C, ideational repetition of content. This showed that those children who were

interested in stories which were characterized by single statement also tended to be interested in stories which were characterized by ideational repetition of content.

8. Correlations revealed no relationship between the expressive behavior responses on these 3 forms of the stories, single statement, verbal repetition, and ideational repetition of content.

9. There was no relationship between extroversion rating and the children's interest and expressive behavior responses to the forms of the story.

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Play Activities of Children in the First Six Grades

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IN connection with the collection of certain other data,[1] children in grades 1 to 6 in certain Minneapolis schools were asked to write in 10 spaces the names of outdoor games which they had played more than once during the previous year, to underline the games they had played most often (as baseball, tag, etc.) and farther down on the same page to make the same record for indoor games (as basketball and authors, etc.). When the material came to be worked up, it seemed unwise to use the underlinings made by the children because it was clear that certain children misunderstood this part of the directions, some underlining all games and some none. The data reported in this paper are, therefore, based merely upon the games listed. If more than ten games were recorded by any child, only the first ten were used.

From table 1 it appears that both boys and girls are consistent in listing fewer games for indoor than for outdoor play. This may mean nothing save that since the outdoor games were always recorded first the child's interest or imagination gave out before the end. It probably, however, is significant since there is some evidence of less community of interest about indoor games than about those played out of doors.

An attempt was made to classify the games which the children listed. Some games named were, of course, impossible to locate; some were not identified because we were unable to untangle the spelling; still other games seemed to be individual plays which for one or two children had become sufficiently formalized to be given a name but which were listed in none of the common books on games. The classification which was finally adopted divided the games into the following classes:

1. Catching, throwing, kicking games (such as baseball, basketball, duck on the rock, marbles, jacks, croquet)
2. Chasing, fleeing games (such as three deep, blindman's buff, king of the hill, pom pom pull away, fire on the mountain, drop the handkerchief)
3. Hiding, seeking games (such as cop and robber, hide and seek, hide the thimble, button button, cowboy and Indian)
4. Jumping, hopping games (such as hop scotch, leap frog, jump rope)
5. Folk dances, singing ring games (such as Soldier Boy, London Bridge,

[1] The data reported in this paper were collected by Mr. Harry S. Clark in connection with work done for a course in Teaching Social Sciences under Prof. A. C. Krey of the University of Minnesota.

Farmer in the Dell, Lazy Mary, Here We Go Round the Mulberry Bush)

6. Informal dramatization (such as house, store, office, dolls, school, show)
7. Following directions (such as do this do that, Simon says, follow the leader)
8. Table games (such as Old maid, Snap, Uncle Wiggly, Parchesi)
9. Very active play which may be individual (such as sliding, skating, swimming)
10. Rather inactive play which may be individual (such as painting, sewing, radio)
11. Group games of the guessing type (such as buzz, telephone, lead man, silent circle, beast bird or fish)

steadily more marked. Of all other games in this group, baseball stands out preëminently. The girls show an increase in interest in the catching-throwing with advancing age but they never equal the interest which the boys show in this type of game. There is little difference in the popularity of the chasing-fleeing games for the two sexes for the ages considered.

With both boys and girls the popularity of the singing-ring games (type V) decreases steadily from age six on. These games are more popular with girls than with boys and the games continue to be played at higher ages than in the case of boys. The hiding and seeking games keep at about the same level with both sexes over a long period of years. Girls show a definitely greater interest in jumping-hopping games (type IV) than do the boys. Although this interest is at no age great enough to make up more than 10 per cent of the total number of games listed, still it never with the girls falls as low as the highest percentage in the case of the boys. Informal dramatization, although never very high for either sex, shows a decrease with advancing age. Games of the type of "do this, do that" reach

TABLE 1

Mean number of games listed by children in various grades

GRADE	NUMBER OF CASES		MEAN NUMBER OF OUTDOOR GAMES		MEAN NUMBER OF INDOOR GAMES	
	Boys	Girls	Boys	Girls	Boys	Girls
1	16	27	8.3	9.1	7.8	8.5
2	75	71	8.6	8.6	6.2	7.5
3	175	173	8.8	8.5	7.3	7.6
4	153	150	9.0	9.1	6.6	7.5
5	152	130	9.1	9.5	7.8	8.2
6	167	134	8.5	9.3	8.0	7.9

Table 2 shows the classification of all games which we could identify. From this table it is clear that among outdoor games the only types that make up any appreciable percentage of the total number fall in the first five types. For boys the preference lies clearly in the catching-throwing games (type I) and the chasing-fleeing games (type II). For ages six through nine, the boys show some preference for the chasing-fleeing games over the catching-throwing games but from age ten on the popularity of the catching-throwing games becomes

a rather low maximum for both sexes at age seven and then gradually decrease. The same trends of interest are shown when we divide the children by their grade in school rather than by their chronological age.

When we consider indoor games, we get the distribution of table 3. croquet game as well as the usual croquet, and since there is an outdoor game of "500" as well as a card game by that name, it was deemed unwise to make any attempt to discard a game listed in the belief that the child had recorded the game in the wrong place.

TABLE 2

Outdoor games—percentages of children of different ages playing different types of games

AGE	TYPE											NUMBER OF CASES
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	
Boys												
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	
6	23	33	22	1	10	5	0	0	5	0	0	105
7	20	51	11	3	6	1	5	0	3	0	1	335
8	27	45	16	3	3	2	3	0	1	0	1	943
9	31	43	19	2	1	1	1	0	1	0	1	1,323
10	39	38	15	2	1	1	1	0	2	0	2	1,360
11	49	29	15	2	0	0	1	0	3	1	1	1,123
12	39	36	17	3	0	1	1	0	3	0	1	348
13 and over	51	30	11	4	0	0	1	0	3	1	0	331
Girls												
6	13	37	11	10	21	5	0	0	2	0	0	168
7	15	48	12	6	7	2	4	0	3	0	2	417
8	19	38	15	10	6	5	3	0	3	0	2	1,032
9	24	41	14	8	3	3	2	0	2	0	2	1,300
10	28	41	14	7	1	1	3	0	1	0	3	1,036
11	34	32	16	9	1	1	1	0	2	0	3	978
12	33	34	14	8	2	1	1	0	3	0	3	462
13 and over	33	33	19	10	2	0	1	0	0	0	1	213

This table is probably less accurate than the tables on the outdoor games. It seemed evident from working with the records that some children failed to distinguish between indoor and outdoor games, but since it is possible to play many games either *outdoors or* inside if we consider the possibilities of a gymnasium, since there is a table

When we compare boys and girls on indoor games we find the popularity of catching-throwing games among the boys not nearly so marked as was the case in the outdoor games. In fact, throughout the list there seems to be *much closer agreement on the games* played by the two sexes except for informal dramatization (type VI) which

is more popular with the girls and the "active play sometimes individual" (type IX) which is more popular with the boys. As might be expected, both sexes show smaller percentages in the catching-throwing and the chasing-fleeing games and much larger percentages in the table games in indoor than in outdoor games.

children in grades above the sixth, it meant that the superior twelve-year-olds would not be included. The seven-year-olds, although few in number, probably represent the children of that age who are in school (exclusive of the kindergarten)

From this array of favorite games it is clear that baseball attains a popularity with boys that is equalled only by the popularity of jacks among the girls. Both boys and girls retain their interest in tag games throughout the ages included. Tag itself is listed among the five most popular games for each sex and every age. Washington poke (a form of tag) appears in seven out of the ten lists and stoop

TABLE 3

Indoor games—distribution of percentages by age

AGE	TYPE											NUMBER OF CASES
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	
						Boys						
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	
6	5	31	11	0	28	13	2	3	1	5	0	96
7	6	18	16	1	26	3	3	24	0	2	0	232
8	13	16	14	1	12	8	2	26	2	4	2	708
9	17	16	12	1	2	6	0	38	2	3	3	951
10	24	13	11	1	3	4	2	35	2	3	2	986
11	26	10	9	1	1	2	2	37	8	1	2	909
12	23	9	12	1	0	3	1	35	11	2	3	333
13 and over	24	5	10	3	2	1	0	39	12	3	2	254
						Girls						
6	8	31	15	1	34	10	0	1	1	0	0	137
7	10	16	13	1	27	10	2	17	2	2	0	336
8	10	20	19	0	8	16	2	16	1	3	4	849
9	11	15	11	1	3	18	1	31	1	2	5	1,046
10	16	17	11	0	4	10	1	33	1	2	6	792
11	21	15	11	1	2	10	1	30	1	1	7	753
12	17	11	13	0	3	8	2	38	1	1	7	342
13 and over	20	13	16	1	4	7	1	32	1	2	3	152

When we consider the individual games (not the types of plays) which are played by most children, we may select the five favorite outdoor (table 4) and the five favorite indoor (table 5) games for ages seven through eleven. There were comparatively few records on children over eleven and since these records included no

TABLE 4

Favorite outdoor games of children of different ages

In order of preference

BOYS	GIRLS
Age 7	
Hide and seek	Hide and seek
Washington poke	Tag
Baseball	Stillwater
*Tag	Stoop tag
Stoop tag	Jacks
Age 8	
Hide and seek	Hide and seek
Tag	Tag
Baseball	Jacks
Washington poke	Washington poke
Stillwater	Jump rope
Age 9	
Tag	Tag
Hide and seek	Jacks
Baseball	Hide and seek
Washington poke	Washington poke
Stillwater	Jump rope
Age 10	
Baseball	Jacks
Tag	Tag
Hide and seek	Hide and seek
Football	Washington poke
Washington poke	Baseball
Age 11	
Baseball	Jacks
Football	Tag
Tag	Hide and seek
Hide and seek	Baseball
Run sheep run	Run sheep run

* Bracketing means that those games were equally popular.

TABLE 5

Favorite indoor games of children of different ages

BOYS	GIRLS
Age 7	
Hide the thimble	Hide the thimble
Checkers	Rig a jig jig
Cat and rat	Checkers
Brownies and fairies	House
*Farmer in the dell	London Bridge
Pop goes the weasel	
Button button	
Age 8	
Checkers	Hide the thimble
Hide the thimble	Checkers
Dominoes	House
Brownies and fairies	School
Cat and rat	Dominoes
Age 9	
Checkers	Hide the thimble
Hide the thimble	Checkers
Dominoes	House
Old maid	School
Basketball	Jacks
Age 10	
Checkers	Hide the thimble
Hide the thimble	Checkers
Basket ball	Uncle Wiggly
Volley ball	Jacks
Uncle Wiggly	School
Age 11	
Checkers	Checkers
Basket ball	Jacks
Cards	Hide the thimble
Hide the thimble	Cards
Volley ball	School

tag, another variation, appears twice. Hide and seek also appears in every one of the lists for both sexes.

If we calculate the percentage of children at the different ages who play the various outdoor games, we find certain definite tendencies for interest in certain games. Both sexes show for the ages considered a steadily increasing interest in baseball, run sheep run,

sixty and tennis; boys show an increasing interest also in: canny can, five hundred, football, golf, horseshoes, hockey, marbles, nigger baby, and volley ball. Girls show increasing interest in jump rope, croquet and long ball.

Both sexes show a steady decline in interest in ball, drop the handkerchief, farmer in the dell, London Bridge, stoop tag and shadow tag. Boys show decreasing interest also in catch, cat and rat, pom pom pull away, statue, wood tag and Washington poke.

Games which increase to a maximum between ages seven and eleven and then decline are for both sexes: cop and robber, hide and seek, send after and tag; for boys alone, Chinese tag, cowboy and Indian, stillwater, lead man, croquet, and duck on the rock; for girls , jacks and Washington poke. Other games either show no clear tendencies or appear so infrequently that the changes in the figures may be due solely to chance.

In the lists checkers and hide the thimble stand out as the greatest favorites with checkers in general preferred by the boys and hide the thimble by the girls. Other points to be noted are that house and school, although appearing frequently on the lists of the girls are not present on any list for the boys; on the other hand, basket ball and volley ball are popular with the boys but do not appear on the girls' list. Under "cards" in the age eleven lists we have not included definite card games listed such as "bridge" or "rummy" but we have clung to the children's own naming and counted only the times the children themselves named "cards."

It is interesting to compare the lists of preferred games given above with the results obtained by Lehman and Witty (1) by a different method. These investigators did not attempt to separate outdoor from indoor plays and since they had the children check items on a printed list, without doubt many were checked which the child would not have thought of if left to write the list by himself. They find that the play activities engaged in most often by children between the ages of eight and a half and ten and a half (roughly the group covered in the present study) were: activities involving (1) pleasurable bodily movements, usually rhythmical; (2) hiding and finding; (3) imitation of adults; (4) a relatively high degree of skill; (5) efforts at construction; (6) activities which depend for enjoyment primarily on sense organ stimulation; (7) tag games; and for girls, at least, (8) singing games and ring games. The Lehman and Witty study and the present report agree that boys of seven and eight are much interested in playing baseball, hide and seek, and tag; that boys of nine are much interested in baseball and basketball; and that boys of ten and eleven are much interested in baseball, basketball and football; that girls of seven are much interested in playing house, hide and seek, and tag; and that girls of eight enjoy hide and seek, jump rope and tag. The two studies fail to agree on any games listed as very popular with girls of nine and over. In general, the two reports agree that jacks,

jump rope, school, house, and the singing ring games are definitely more interesting to the girls, while the ball games, marbles and athletic contests are more interesting to the boys.

SUMMARY

1. This paper summarizes lists of outdoor and indoor games which Minneapolis school children from grades one to six recorded as having played within the past year.

2. Of the outdoor games, those of the types of catching and throwing, chasing and fleeing, and hiding and seeking games were most popular with boys and girls of all ages.

3. Boys show more interest than girls in certain games such as the catching-throwing games while girls show more interest in jumping-hopping games.

4. Of the indoor games, the same types appear popular as for out-of-door games with the addition of table games and games involving simple dramatization.

5. Of indoor games boys seem to play catching-throwing games more than girls, while girls play at informal dramatization more than boys.

6. Of the outdoor games listed most frequently tag and hide and seek are universally popular. Boys show especial interest in baseball while girls show considerable interest in jacks.

7. Of the indoor games, checkers and hide the thimble are popular with all ages and both sexes.

8. Older boys show considerable interest in basket ball and volley ball. Girls play jacks indoors as well as outdoors.

9. The findings of this study agree fairly well with those reported by Lehman and Witty.

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Continuous Reaction as a Measure of Attention

MURIEL W. BROWN

THE PROBLEM

ABOUT six years ago, the present writer conducted a simple word learning experiment with a small group of children ranging in age from two and a half to four years. The task, in this instance, was to learn to recognize a number of printed words by associating them with toy objects which they represented.

At the close of the investigation we found marked individual differences in achievement. We also discovered that these individual differences did not correlate highly with intelligence as measured by the Stanford Binet I.Q. Some relatively dull youngsters with a certain placidity of temperament accomplished more, under the given learning conditions, than other, brighter, children who seemed unable to focus upon the problem for longer than a few seconds at a time. This tendency to distractibility was more marked with the younger subjects but appeared at all chronological age levels. We further noted that wherever this inattentive behavior appeared it had certain fairly well defined characteristics. Movements were mercurial,—particularly eye movements. There was marked diffuseness of energy output, with little evidence of control. Response to the test situation seemed to be, not integrated effort under the direction of a persistent idea, but rather, a series of fairly discrete reactions to an environmental kaleidoscope of stimulus patterns.

These observations raised a number of interesting questions in regard to the nature of attention. With this group of children, physical, intellectual and emotional factors seemed to be nicely integrated in the attentive states. What interfered with the coordinating of processes in the inattentive states? Is inability to control attention an organic, an emotional, or an intellectual defect? Does the power to attend develop gradually in small children with measurable increments between chronological age levels? Can attention be measured at all?

The following study is an attempt to explore a small corner of this very large and interesting field. It aims to deal with three aspects of the problem:

1. The measurement of attention
2. Acquisition of control of attention
3. Individual differences in attentivity

An experimental situation has been devised which rules out, as far as possible, known conditioning factors. Success depends primarily upon attention to the task,—a simple repeti-

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tive process. The subjects are young children with no previous experience in this sort of thing. The set-up is a modification of the continuous reaction apparatus.

REVIEW OF THE LITERATURE

It has been somewhat difficult to relate this experiment to the older psychological work on attention, first, because it began as a frank exploration, planned to yield data which would suggest, rather than test, hypotheses; second, because of various confusions in terms. A review of the literature discloses so many definitions of attention that one is lead to wonder whether James could possibly have intended to include psychologists when he said "Every one knows what attention is."

The earlier writers (pre-18th century) regarded attention, in the main, as "an unanalyzable attribute of the soul—evidence of the independent activity of the mental principle." (3, p. 86). The majority of English empiricists (particularly Hume, Hartley, and Spencer) ignored it, perhaps, as James suggests, because it could not be treated as a pure product of experience. The Germans before Herbart "explicitly treated of it," but "either as a faculty or as a resultant." (35 p. 402). The literature of the late 19th century bristles with theories which Baldwin (3), p. 86) classifies as:

1. The affective.

   "Attention is an intellectual monoideism accompanied by spontaneous or artificial adaptation of the individual." There are two kinds, spontaneous and voluntary. Spontaneous attention is the rudimentary form and is the outcome of the natural impulses and desires; its essential elements are the motor processes. Voluntary attention does not differ in kind, but is later in the order of development, and "depends upon the emotions or impulses acquired by education." (72, p. 6.)

2. The "psychical energy" and "original activity" theories, (Lotz, Wundt, Stumpf, Ward, Ladd, etc.).

   Attention is defined in terms of degrees of consciousness. "We are, at the moment more conscious of some objects than of others, and it is the objects of which we are most conscious to which we are said to attend, or which are said to be 'clear'." (42, p. 597.)

3. The conative and motor theories, (Bain, Lange, Munsterberg, Stout, Baldwin).

   "That the ideational preparation itself is a consequence of muscular adjustment, so that the latter may be called the essence of the attention process throughout." (35, p. 444.)

4. The "intensity" and "reinforcement" theories, (Condillac, G. E. Muller, Bradley).

   These assume central sensory reinforcement of peripherally excited or centrally prepared sensations or ideas. (40, p. 444.)

5. The "inhibition" theory, (Ferrier, Alexander, etc.).

   "The physiological or psychological principle underlying every act of attention is inhibition in order to concentrate,—the shutting out of irrelevant matter in order to examine some central point." (2, p. 295.) "The changes which conscious contents undergo in one state of attention, and the motor phenomena which follow in its train admit of two interpretations, one of which accredits attention with functions both of reinforcement and inhibition, while the other attempts to explain all the facts in terms of inhibition alone." (40, p. 444.)

These brief quotations will suffice to give a bird's-eye view of the range of thought upon the subject under discussion. It is clear, as Külpe points out, that psychology has "confused in its idea of attention, three very different notions: that of a faculty, the operation of which produces certain changes in the mental life; that of an activity, the activity of remarking, noticing, observing,—always directed upon some definite content which is the occasion of its exercise; and that of a state in which we continue for a longer or a shorter time, unaffected by changes in the content of our consciousness." (41, p. 42).

"Contemporary psychologists," writes H. M. Johnson, "make use of a single term 'attention' to designate two variables, indifferently. One of these variables is the degree of consciousness, or the clearness of content; the other is the degree of the sensory and motor adjustment of the organism with respect to a particular stimulus." (37, p. 601). Since Woodrow (92), in 1916, argues at length for a "faculty" of attention, we may doubt whether the number of issues has been so far reduced as Johnson supposes. It seems to be true, however, that the concepts to which he refers have a general acceptance, and that as he further states, "two representative authors," Münsterberg and Dunlap are able to combine the two views in a theory of attention which specifically postulates that "the 'degree to which one is conscious,' or the 'clearness and vividness' of content, is determined by the degree of adjustment for reception and response; the latter being perhaps theoretically expressible as some function of the number of different pathways which combine in producing the appropriate response." (37, p. 604.) In other words, integration and attention,—consciousness, too, if you like,— are the same thing. It is surprising—and interesting,—to see how much of the old obscurity vanishes if the earlier theorists are translated into the language of modern scientific psychology.

The specific problems attacked in experimental studies of attention Baldwin (3) groups under the following heads: (1) Fluctuation of attention; (2) complication; (3) range of attention; (4) distraction of attention; (5) influence of attention on the estimation of time intervals; (6) reading time experiments; (7) attention and concomitant processes, physiological and psychological; and (8) the effects of attention.

The experimental work done between 1874 and 1908 has been admirably reviewed by L. R. Geissler (29), with special reference to method. He distinguishes between (1) the general means of inducing variations of attention, and (2) the special means employed for the measurement of these variations. Under (1) he divides procedures into the "single-task," or distraction method, and the "double-task," or the method of simultaneous activities. The "single-task" method was first used in 1874 by Wundt (93) and Obersteiner (60) who attempted to measure attention by means of reaction time using auditory, cutaneous and visual distractors. Distractors of many kinds have been used since then in a wide variety of experimental situations.

The "double-task" method was first employed by Loeb in 1886, to find out whether muscular activity could be used as a measure of mental activity. His work was later extended to include the correlation of the muscular strength of the hand with many different mental activities, such as visual and auditory perception, mental addition and multiplication, reading, writing and repeating poetry. In this connection the names of Münsterberg (56, 57, 58, 59) W. G. Smith (76), Drew (17), Binet (4), and Henri (34) should be mentioned, also those of McDougall (50, 51), and, particularly, Wirth (89). Experiments with both methods show that with different people the same distractions have different effects but the results are unreliable, depending largely upon the effectiveness of the distraction material as such. Distraction material may be ineffective, (1) because of lack of continuity, which permits the other task to rise, at moments, to the focus; (2) because of adaptation; (3) because of the improbability of getting distraction material which affects all normal subjects in the same way. (29, p. 492.)

The methods proposed for, or employed in, the measurement of attention, Geissler divides into six groups. "The first five may be classified as methods of expression. According to these, degrees of attention may express themselves in changes of, (1) peripheral vision; (2) muscular strength; (3) liminal and differential sensitivity; (4) reaction time; (5) accuracy of work. The sixth method may be likened to the method of impression. By a series of graded distractors, degrees of attention are to be induced in the observer, and he is afterwards to report which degree he experienced." (29, p. 492.)

Method 5 is essentially the method of the present experiment from the point of view of treatment of data, and, therefore, has a special interest here. This method "seeks to find an expression of the degree of attention in the quality and quantity of the work performed in a given time." Jodl (36, p. 84–85) says of it, "It is obvious that attention cannot be measured directly. However, its degrees may be determined indirectly by reference to its effects. These effects consist, in every task which does not have the character of an involuntary movement, in the avoidance of errors and mistakes and in the quickness of the execution." Stern (77, p. 84) also holds that "the quality and quantity of a task performed under normal conditions could be used as a measure of the attention energy."

Friedrich (26) first suggested a modification of this method in 1883 "It is tempting," he writes, "to fix definitely the somewhat unsettled concept of attention by making it proportional to the measure of precision, i.e., to the reciprocal value of the mean error, so that a small mean error corresponds to a high degree of attention, and conversely a large mean error to a low attention,—since the characteristic phase of attention consists rather in the large variations of the physiological times within the same experimental series." (26, p. 73.) He warns, however, that "only in cases of the simplest mental processes, which besides should be as homogeneous as possible, and

little subject to practice, may one assume that the mean error is mainly dependent upon the degree of attention. With more complex mental processes not only does practice play a considerable part in the fluctuations of the individual experiments, but, in certain cases, the cause of great variations may lie in the mental processes themselves." Oehrn (62) had 10 subjects count letters, look for certain letters, read proof, etc., and "made a wide application of the mean variation as the 'dynamometer of the attention'." (26) He found significant individual differences in variability and, particularly, differences in the kind and amount of attention given to the various tasks. Henri criticizes Oehrn's conclusions on the ground that factors like fatigue and practice were not eliminated, and certainly must have influenced the mean variations. Peters (63) found a close connection between the magnitude of the mean variation in determinations of liminal sensitivity and the degree of attention under which he had established the limen, "but assumed that" practice had a slight but distinct effect upon the results. Geissler suggests that the mean variation can best be used as a check upon conclusions drawn from other techniques.

Since 1908, experiments in the field of attention have touched upon all of the eight main problems outlined by Baldwin, tending of late years to center about either the clearness or the muscular adaptation hypothesis. Geissler (29) reports, on the strength of a study of fluctuations of attention to cutaneous stimuli, that "under good conditions, attention focused on liminal and subliminal sensations remains approximately constant for at least two or three minutes, and then gradually fades," (through adaptation). In 1909, he tested "the assumed parallelism of the expression methods" by correlating "the accuracy and quantity of work performed with the muscular rigidity or motor inhibition which is said to become the more pronounced the more attention is concentrated." (29, p. 503). He found "a very close parallelism . . . to exist between introspectively distinguishable variations of attention and corresponding differences in the precision of work performed at these levels under the condition that the estimation of degrees of attention was made in terms of clearness and that the work itself was not influenced by anything else but change of attention." (29, p. 529.)

Experiments for 1910 have to do particularly with Wirth's (89) method of measuring distribution of attention,—the method of liminal differences for brightness in different parts of the visual field under varying distributions of attention. Lipps (44) repeated Wirth's experiments and in general, confirmed his results, finding that the central and lower portions of the field were materially favored. The influence of attention in this situation is not clear, according to Pillsbury. Whipple (88) tested the mind-training theory proposed by Miss Aiken (1) and found but a negligible improvement in visual memory span for letters or objects, although his subjects were trained by 100–200 exposures. Dunlap (18), 1910, worked on the complication experiment and found three general methods of judging the posi-

tion of the moving pointer at the moment of a discrete stimulus, each of which produced a characteristic quality and quantity of error. Billings and Shepard (5), 1910, studied change of heart rate with attention and decided that the primary effect was in the respiration rate, which in turn affected the heart rate. There is frequently restricted breathing with sensory attention, they assert, which decreases the heart rate; with central attention there is little change in breathing, but a slight tendency to increase.

McComas (47), 1911, made an interesting study of types of attention, using various kinds of material in a field exposed by means of a tachistoscope. He found, in general, two types of attentional activity,—the broad and the narrow spanned. Subjects who were broad for visual were also broad for auditory span. Two other types were discovered—the alert, active, quickly controlled, and the sluggish, the former being broad-spanned. Intercorrelation of the data showed that the ability to concentrate and inhibit did not appear to be closely related to any other marked traits of attention. Prager (64) worked on the relation between defects of attention and control of association and found that disturbances of functions in the two fields went hand in hand. In a study of the effect of alcohol on attention, Busch found a narrowing of the field after 30 cc. of alcohol, (9).

The relation between attention and breathing was reexamined by Suter (79), 1912, who points out a difference between strain of attention and concentration. Feilgenhauer (22) in this same year worked on rate of change of attention with disparate stimuli (visual and auditory). He found "the smallest active step of attention to be 300 sigma, with little change of limits for different kinds of stimulation." He also discovered that the shifting of attention from stimulus to stimulus was smooth if stimuli were in the same realm, otherwise not. Rate of change, which, he thought, depended on the personality of the observers, could not be voluntarily accelerated, although it could be voluntarily slowed. Rate of change did not appear to be affected either by position of optical stimulation, direction of movement, or increase of stimulation.

Five papers in 1913 dealt with direction of attention. Flügel, (24, 25), used figures drawn in double perspective, and decided that direction of attention was the prime factor in reversal, and that local fatigue was not of importance. Billings (6) measured the duration of attention to supra liminal stimuli and found the maximum much smaller than the so-called attention wave. His 21 subjects gave a median of 1.69 seconds for duration of attention to a small object. Pillsbury (66) points out that if each recorded change in this case is thought of as two waves,—change, and awareness of change,—the resultant value corresponds approximately to Sherrington's refractory period of the reflex, and also to "a number of times in different mental operations that have been referred to the attention wave, or that probably have approximately the same conditions in the nervous systems." (66, p. 169.)

Martin, Paul and Welles (46), 1914,

tested the validity of the use of the sensory threshold as an index of the general state of the nervous system, comparing the threshold of the winking reflex, secured by faradic stimulation of a selected spot on the lower lid, with the sensory threshold for the same spot on the lid. Results showed that the reflex threshold tended to vary from its mean value less than the sensory threshold. The fact that "direction of divergence" was nearly always the same for the two types of limen was taken to mean that the attention, under the conditions of these experiments, manifested itself as a function of the condition of the higher brain centres. The authors conclude that the value of the sensory threshold depends on the state of the higher centres and that the threshold may justly be used as an indicator of such state. Woodrow (90), 1914, published a monograph on the measurement of attention which he followed with a paper in 1915 (91). He deals particularly with reaction to surfaces with sharp outlines, with and without the distraction of a warning signal occurring at irregular intervals before the stimulus. The conclusion seems to be that irregular intervals of this nature increase reaction time, (presumably because they do not coincide with the attention wave), but have less effect when the outline of the stimulus is clear.

In 1916, Woodrow (92) applied his method of distraction by means of irregular preparatory intervals to a study of the reactions of 12 subjects to touch, sound and light stimuli. His results led him to conclude that the mode of stimulus is a condition of attention. Marked individual differences were found but these, although differing in magnitude for the several cases, were found to be relatively the same for each type of stimulus. Woodrow concludes that "the degree of attention of any individual is conditioned in part by certain general conditions which remain constant while the type of mental process concerned is varied," and that "it is to these general conditions alone, are due the individual differences in degree of attention found in the present investigation," (92, p. 317). Curtis and Foster (12), also in 1916, studied the effect of changes in intensity and size upon the clearness of a Greek cross, and found that change in size has no effect. Clark (11), 1916, conducted an experiment in visual imagery and attention from which he concluded that (1) "changes in the clearness of the image correspond, to an appreciable extent, to the movements of the eyes; that ocular movement is more likely to occur in secondary attention than in primary or derived primary attention; and that characteristic ocular movements, and possibly general motor attitudes seem to be transferred from visual perception to visual imagery. (2 subjects.)

Morgan (54, 55), 1917, reëxamined the problem of attention during distraction and found that although 13 of his 21 subjects suffered a brief diminution in capacity at the beginning of distraction all but 4 finally gained. The measurement of incidental movements showed that increased capacity was the result of greatly increased force.

McQueen (52), 1917, found no correlation between the ability to distrib-

ute in one task and in another. He used the correlation method in the treatment of data obtained from 40 school children. He concludes, from his study that the capacity to distribute is specific, and adds that he found a low correlation between success in distribution and teachers' estimate of intelligence. The coefficient of correlation is highest for tests requiring concentration, and is negative for motor tests.

McComas (48), 1917, publishes an account of a new apparatus for recording continuous discrimination reactions, an apparatus very like the one used in connection with the present experiment. McComas' subjects reacted to four differently colored lights by pressing different keys. The lights appeared upon an exposure screen and the instant one colored light was extinguished another appeared. The order of appearance was miscellaneous and not repeated for 60 exposures. The rate of exposure was controlled by the subject and the records were taken off on a smoked drum. "A marker in circuit with the armature of the clock registered each correct reaction, and a marker in circuit with the reaction keys scored all reactions made."

Lobsein (45), 1919, gave Münsterberg's motormen's test to 12 children as a measure of attention and obtained a high correlation (r = .84) between intelligence and the test results. His criterion of intelligence was the ability to meet new demands, (made by tests of his own devising), quickly and accurately. He found, also, an inverse relation between extent and efficiency of attention.

Liddell (43), 1920, tested Ferree's theory that attention waves are due to adaptation of the part of the retina stimulated and got no relation between eye-movement and fluctuations of attention. Bowman (7), 1920, in a study of size vs. intensity as a determinant of attention found that "the left hand position is the more favored."

Fernberger (23), 1921, stresses the importance of range of visual apprehension as distinguished from range of attention. He points out that the statistical limen is a more reliable and more readily determined measure of the latter than any of the classical methods of getting span, since "in the range of apprehension one is interested in determining the number of objects the correct apprehension of which has a probability of 0.5." He finds that the observed relative frequencies of correct judgments follow a continuous function of ogive form, and that the individual limens in his experiment ranged from 6 to over 11 stimulus objects. (dots.)

Dallenbach (13, 14), 1922, compares position with intensity as a determinant of clearness and finds that "the left hand position and the position above have the attentional advantage, and that the most advantageous position of all is the position to the left and below the point of fixation.

McComas (49), 1922, used his continuous discrimination apparatus as a measure of attention in an experiment with 11 adult subjects. In the treatment of the results he considers particularly the relation between right and wrong reactions, assuming that "the

increase of the wrong reactions is an indication that the subject is relying less upon careful discrimination and choice of reactions and more upon chance, (which thus) becomes the prominent factor in the situation." (49, p. 7.) On the strength of this assumption, all of the wrong reactions were regarded as chance reactions, with the probability that 75 per cent of the chance reactions were wrong. This, according to McComas, left 25 per cent of chance reactions which were right. He, therefore, derived his scores by subtracting one-third of the number of wrong reactions from the total number of rights. During the past winter, the present writer has had many opportunities to note the great variety of circumstances which led, in the case of her five year old subjects, to the final pressing of the wrong key. In the light of the children's behavior, McComas' assumption of the nature of error seems somewhat unsatisfactory, and probably lessens the significance of his conclusions. His subjects reacted continuously for periods of ten minutes, and the scores show "marked differences in speed and accuracy of reaction and in the temporal variations in these factors." Reaction times were taken.

Dockeray (16), 1922, reports experiments with the sounder test, which he recommends highly as a test to determine individual differences in ability to overcome distraction. H. M. Wells, (87), 1922, notes that during a "choice" reaction there is a fall in resistance, indicated by the psychogalvanic reflex.

Griffiths and Gordon (31), 1924, go again into the question of the relation between Traube-Hering waves and attention rhythms and find a slight correspondence, which they attribute to the vasomotor changes accompanying attention and the motor responses associated rather than to the Traube-Hering rhythms themselves. Oehrn (62), 1924, repeated the classical "range of attention" experiment, using psychophysical procedure, and concluded that practice tended to increase the value of the threshold.

H. M. Johnson, (37), 1925, considers the "clearness" experiments of Cassel and Dallenbach (10), and shows by further statistical treatment of the original data that "the precision with which any particular value of clearness, Y, can be inferred from the corresponding reaction time, X, is but 3 per cent greater than the precision based on a mere guess from the average My—in other words" there is no proof here (as the authors claim) that the reaction time is determined chiefly, if not entirely, by the degree of adjustment for reception and response.

For a resumé of the work done between 1925 and 1928, the reader is referred to Dallenbach (15). Dallenbach classifies the studies published during these three years in four groups, as follows:

1. Those concerned with the definition and ultimate nature of attention.
2. *Those dealing with some special aspect* of the subject, such as range, fluctuation, etc.
3. Those that treat of attention in relation to some other phenomena.
4. Those that are technological.

Nothing reported under 1 is of special interest in connection with this paper

except possibly a bit of nursery school research (Bertrand) in which an attempt is made to differentiate between spontaneous and voluntary attention in 36 children ranging in age from two years two months to six years. The author of this investigation finds that the length of time his children attended to a game varied greatly for different days. He reports an age and sex difference in the duration of this type of attention, and also finds that the means vary on different days of the week and on the days following holidays. One suspects that the measurements in these situations were affected by a good many other factors besides attention however defined.

With respect to 2,—special aspects of attention,—Dallenbach finds a wide range of studies of varying interest and importance. There appears to be a marked tendency among experimenters to agree that "the question of range is not a proper one to ask regarding attention. *The attentive consciousness is an integrated whole;* and as such the range of attention is unity." It seems also to be agreed by most writers that so-called fluctuation of attention is a question of limen. Dallenbach and Johnson continue their debate on the problem of measurement, Dallenbach stressing again his thought that by a proper treatment of reaction times it may be possible to discover the relations existing between clearness and reaction. Sterzinger (78) reports the results of a study of distribution of attention. His subjects added continuously while listening to the reading of a short story. The author concludes that generalization from this type of experience is risky, since it is difficult to tell under such conditions whether one is dealing with simultaneous or with rapidly shifting attention.

Several papers during this period dealt with the relation of attention to other phenomena, Dallenbach's third classification. Dallenbach describes an "attentional learning board" devised by Roberts and Farnsworth. With this apparatus, the rapidity with which the problem is solved depends upon the subject's attention to details.

Under 4, we find some discussion of tests of attention. Sterzinger (78) points out that such test results are significant only in so far as they test special abilities.

A paper by Skawran (75), is interesting in that it makes a more theoretical attack upon the problem of attention, and contains the statement that "all volitional decisions (as in choice reactions) are to be attributed, in greater or less degree, to feelings and strain sensations."

Verwoerd (84) in 1928, published a paper on the testing of distribution of attention. His subjects reacted to the flashing of stimulus lights by pressing corresponding telegraph keys. He found large individual differences in general efficiency and evenness, but concluded that the two were not correlated. The nature of the set-up makes a detailed analysis of this relationship difficult if not impossible.

In 1929 we find several studies of some importance, a number of them coming from German laboratories. Kindler (39) investigates training of attention, using the Bourdon test for typing, adding, etc., and getting his subjects to report on introspections.

He concludes that training in certain situations is possible but that such training is influenced by a variety of conditioning factors.

Enke (21) studies the splitting of attention in relation to constitutional type, and finds that results are not influenced by differences in the ages of the subjects. He infers from this that age does not influence the constitutional type. With this investigation, Enke enters a fascinating field and one but little explored. Studies of this kind are quite likely, eventually, to give us a technique for diagnosing in young children incipient psychotic trends.

Wallon, in France (85) investigates the psycho-physical causes of inattention in children. The author avoids the use of the term attention as ambiguous but finds that "nearly all the causes leading to *in*attention are correlated with motor disorders."

Perhaps, after all, this negative approach gives us one of our best clues to the real nature of attention. The long attempt to subtract an attentive process from other mental processes has obviously failed. On the other hand all of the experimental work done, even those investigations based on the older hypotheses, seems to strengthen the major premise of modern scientific psychology—the concept of an integrated organism reacting to stimulation as a whole. One now finds the terms "attention," "dominant pattern" and "integration" all used in the literature with essentially the same meaning to describe this totality of response. We pick up the thread in our present study by making this our working definition.

ORGANIZATION OF THE EXPERIMENT

Re-statement of objectives

The general purpose of this investigation has already been stated: We aimed to experiment with the problem of measurement, to study the question of control, and to analyze certain individual differences in attention to a given stimulus—response situation. We defined attention as the integration of all relevant processes, physiological and psychological, in a total response pattern. Proceeding from this definition, we made the fundamental assumption that a measure of efficiency in performing a simple motor act is also a measure of attention.

Method of approach

The next step was to find a response situation in which learning, fatigue and distraction were essentially non-operative factors. The response must be selective, since it is this element of selectivity which differentiates attentive behavior from the predominantly reflexive type. The familiar continuous reaction experiment seemed admirably suited to our purpose in that it required a selective reaction; the learning involved was extremely simple; and certainty and accuracy of response could be measured with relative ease.

Apparatus

The basic set-up chosen for this experiment was Dunlap's LVN apparatus described elsewhere in detail by the author, (20). This requires the subject "to react to the flashing of a row of miniature lamps by a specific movement in reference to each lamp in the row." (20). This "specific

movement" is the pressing of one of a row of telegraph keys corresponding to the row of lights.

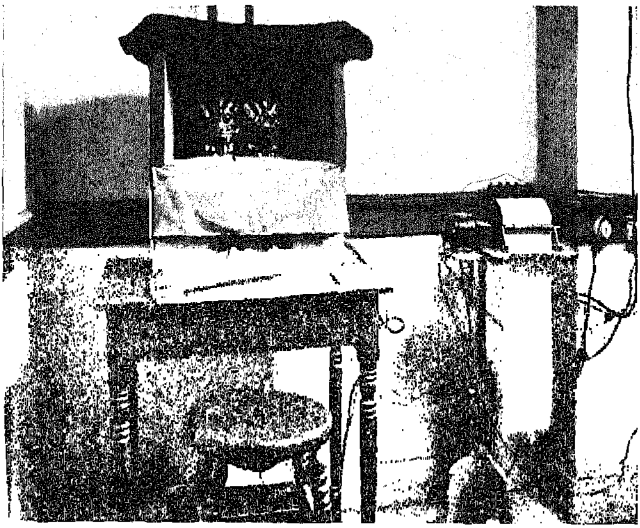
The equipment consists of three main parts,—the switchboard with the lights and the telegraph keys, the mechanism which controls the flashes, and the kymograph which records both stimuli and responses.

Our switchboard was unique. In the original experiments this bit of the apparatus had for stimulus lights 4 small incandescent bulbs arranged in a horizontal row. In order to make the experience intrinsically interesting to our young subjects we placed these bulbs behind the eyes of two tin cats (identical twins) and fastened these cats side by side in such a way that the bulbs were equidistant and in a horizontal row. The cats were a neutral gray and were mounted in a box lined with dark gray flannel 47 x 31 cm. on the side. (See plates 1 and 2.) Each cat was 15 cm. in height, and each eye $2\frac{1}{2}$ cm. in diameter. The eyes, as they flashed, were a glowing green with small, round, red pupils. The children sat upon a stool facing the lights in such a position that the natural point of visual fixation was a spot (not marked) on the back of the box half way between the two middle lights. There was nothing within the range of vision that could compete with the light flashes in stimulus value.

The side of the box upon which the cats were mounted was set upon a stage 25 cm. above the table top on which we built up this part of the apparatus. Below the stage we lined up the 4 telegraph keys in such a way that each key was 28 cm. below and in a line with one of the eyes. These keys were fixed in a vertical position so that to tap them the child pushed forward instead of down. Upon the table top, in front of the row of keys, we put a low platform 5 cm. high covered with the same gray flannel which lined the box. On this the children rested their forearms while reacting with the fingers. On the hand rest, under the flannel, in front of each pair of keys we fastened two little wooden cylinders, about where the hands would lie. These served the double purpose of supporting the palms and of keeping the fingers from resting too near the keys.

The flashing of the lights in the eyes of the cats was controlled by a machine made in the Hopkins Laboratories according to Dunlap's specifications. Dunlap's description (20) follows:

"(There are) four contact wheels, cut from brass, with bakelite filling between the contact lands. Spring brushes resting on the peripheries of these wheels provide reliable contacts and breaks. These contact wheels are rotated by four worm wheels on their respective shafts, all four worm wheels being driven from a single worm shaft on which are cut two worms, two worm wheels being driven from each worm. The worm wheels have respectively 101, 103, 105 and 107 teeth so that although the series represented by one wheel repeats itself after a certain number of minutes, the four series are steadily changing with relation to each other, and the four series return to their original relation only after 343, 824, and 705 rotations of the worm shaft. . . . . The stimuli may occur singly, or two, three or four may occur simultaneously. The lands of the contact wheels are of equal angular measure, but distributed on each wheel in a carefully planned irregularity. The length of time each stimulus lasts, (the length of time each lamp remains lighted), and the average interval between stimuli, in each of the four series is determined by the speed of the rotation of the worm-shaft." (20, p.



THE CATS, THE KEYS, AND THE KYMOGRAPH

Christine Approximately in the Reacting Position

137). The worm shaft is driven by "a synchronous motor of a greatly improved model, so that the timing is extremely accurate."

The rate of stimulation was determined in a more or less arbitrary fashion. Several five and six year old children were tried on the apparatus before the experiment began in order to find out approximately how many flashes they could respond to in a working minute without showing signs of distress. On the basis of these observations the following rate was tentatively adopted: 4.5 flashes per key per minute, mean variation .12; average number of flashes for all keys per minute 18.05, mean variation 1.01. Each flash lasted approximately two seconds. The apparatus was set for this speed for the first 4 subjects, but this initial rate proved to be too slow. The children learned the task quickly, and, naturally, lost interest during the seemingly long waits between flashes. It happened one day toward the end of these first series that the adjustment of the motor was disturbed in such a way as to double the number of stimulations per minute. The child reacting was not disturbed, producing, on the contrary an excellent record. We, therefore, discarded the first 4 sets of records from the main series and established a standard procedure as follows: For the first three series, an initial rate of 4.5 flashes per key per minute, (m.v. .12); for series IV to X, double speed with an average of 10.4 flashes per key per minute, (m.v. .22). The duration of the short flash was approximately one second.

Stimuli and responses were registered by a kymograph of a model (designed and built in the Hopkins shop) which has 4 ink pen writings on continuous paper. This kymograph stands on the floor, on its own base. Each pen is hooked up in a circuit with one stimulus light and the corresponding response key in such a way that we obtained the following records for each separate light and key: "(1) A record of each stimulus whether reacted to or not. (2) A record of each reaction to a stimulus whether occurring before, during, or after the stimulus. (3) A record of each "wrong" reaction, each pressing of the wrong key." (20, p. 138.)

The entire apparatus was set up in a small room, 5 feet, 5 inches by 9 feet, 6 inches by 9 feet, which contained nothing else. Ventilation was by means of a window opening on an air shaft, and a door. The room was lighted by an electric bulb in the ceiling. The "Cat-box" was in a corner against a dull, buff-colored wall. Kymograph and motor were behind the reactors, and screened off. Fortunately both motor and kymograph worked with a minimum of noise.

Subjects

Our subjects were 20 white, five year old children, 12 girls and 8 boys. We limited ourselves to an age range of two months, using only those children whom we could test within the month preceding or following the fifth birthday. The difficulty of finding children of exactly the right age precluded the possibility of selection on any other basis. Public records of births, from which preliminary lists of five year olds might have been compiled, were not available to us. It was necessary, therefore, to hunt up our subjects one

by one. Most of these finally came through teachers in two public schools, through mothers in child study groups and through members of the Johns Hopkins faculty. When all other sources of supply failed to produce the right kind and number of children, we sought out populous streets and rang the door bells!

The group, as finally constituted, represented no one social level. The majority, 13, of the children were sons and daughters of business men. Of the remaining fathers, four were in

TABLE 1

Descriptive data for each subject in the experimental group

Nationality of All Children: American.
Chronological Age of All Children: 5 years ±1 month.

NAME	I.Q.	MENTAL AGE	NUMBER OF CHILDREN IN FAMILY	POSITION OF THIS CHILD IN FAMILY	SCHOOL EXPERIENCE	NATURE OF FATHER'S OCCUPATION	SPECIAL INFORMATION
Ada	123	6–2	2	Older	Kindergarten	Profession	
Amy	123	6–2	3	Second	No	Profession	
Bertha	103	5–2	1		Kindergarten	Business	
Betsy	120	6–0	1		Kindergarten	Business	
Brinton	132	6–6	2	Older	No	Business	
Bruce	83	4–2	1		No	Business	
*Christine	130	6–6	1		No	Business	
Deborah	145	7–2	1		Kindergarten	Profession	Father dead, mother working
Dolly	117	5–10	5	Youngest	No	Business	
Edith	80	4–0	2	Older	No	Mechanic	
Esther	145	7–2	2	Older	No	Business	
Harold	90	4–6	2	Younger	No	Business	
Jessie	102	5–2	4	Third	No	Profession	Father dead, mother working
John	105	5–3	1		No	Business	Parents divorced
Laura	123	6–2	2	Younger	No	Business	
Martin	80	4–0	6	Fourth	No	Street car conductor	
Molly	113	5–8	3	Oldest	Kindergarten	Profession	
*Peter	116	5–10	2	Younger	No	Business	
Robert	105	5–4	4	Youngest	No	Business	
*Spencer	113	5–8	2	Younger	Kindergarten	Business	

* Jewish.

professional work, one was a mechanic, and one a street railway conductor. In the remaining case, the father was dead.

Nothing definite was known of the nature of family relationships in the homes from which our children came. In 18 cases the child appeared to be living in a normal home environment. In one case the child and her widowed mother made their home with maternal relatives, the mother working. Also in one case, the parents were divorced, —the child living with its mother. Three of the children came from a large, fashionable apartment house, two from homes of apparent poverty, the rest from nice, "average," American families. Three of the youngsters were Jewish, the rest American Gentiles. Six subjects were only children. Five were already in kindergarten. This data are summarized in table 1. The names used in this report are fictitious.

Daily program

The experiment proper was, of course, the "working" of the Cats. In order to make the children's approach to the testing situation as easy and natural as possible this "working the Cats" was not emphasized in any way but was presented to them, without particular comment, as one of the lessons in a varied school program.

Through their mothers the youngsters were invited to attend two weeks of kindergarten at the University. Although constant for each one, school time was not the same for all subjects since in most cases our schedules had to be adjusted to household routines. For the same reason it was impossible to have equal numbers in the groups. Five of our children came alone, the others in twos and threes. The testing period lasted for ten days, every effort being made to have these days consecutive. In only one case was there a significant break in the series.

The school program was carefully planned to establish rapport. The children were called for each day at the time agreed upon, brought to school in an automobile, divested of hats and wraps, and taken into the "schoolroom." This "schoolroom" was, in fact, a corner of one of the big laboratories, screened off from the rest of the room. Here a rug, three small chairs, a long low table and one or two bright posters gave a workshop atmosphere to which the children responded readily; toys and constructive materials,—colored papers, crayons, scissors, paste, etc., were kept nearby in a convenient cupboard which formed one wall of our "room."

On his first day of school, each child was given the Stanford Revision of the Binet Scale, and was allowed to make friends with the Cats. For the rest of the days of each series the schedule was about as follows:

1. Construction with paper. 30 minutes. The projects were simple,—paper lanterns, posters, calendars, etc. The children worked intently and carried home the finished objects with pride. This preliminary lesson period gave the youngsters time to adapt to the new environment, and secured a positive coöperation which, in all cases, seemed to carry over into the experimental situation.
2. Toilet
3. Experiment proper,—"Working the Cats." 10 minutes

4. Stories and games. 30 minutes
From time to time, at this period, we introduced certain standardized performance tests. These gave us data which will be used elsewhere in working up another aspect of the experiment. They will not be referred to again in this paper.

We were fortunate in being able to win and to hold the interest of all of the children, each one of whom protested vigorously when his two weeks of school were finally over.

Experimental procedure

The procedure outlined for the experiment proper was rigidly followed. When a child was first taken in to see the cats he was allowed to feel them, to look about the room, if he so desired, and to watch the eyes flash for a while. He was then set squarely on the stool facing the apparatus and instructed in this way:

"You see these two tin cats? Each cat has two eyes, hasn't it? And each eye shines very bright when the little light goes on inside. Now look at these buttons (pointing to the keys). There is one for each eye. Show me which one goes with this eye (pointing to the one in the extreme left). Which one goes with this eye? With this one? With this one? All right. Now, I want you to put your hands here—this finger on this button, this finger on this button (demonstrating for all four). You are to learn to press the right button as soon as you see the light in the cat's eye. Press each button just once, *hard*, all the way down, and let it right up. Now. Let's try!"

A minute of preliminary practice was given, no records being taken of this. The experimenter then explained that, after working, the cats must rest, and dropped the black curtain over the box. After one minute, the curtain was raised again and conmands were given sharply in the following order: "Hands ready." "Ready." "Go." At the word "Ready," the experimenter pressed the button which started the kymograph. We did not time the warning signals, but tried, in each case, to catch the child at the first instant of apparent readiness after the hands were in place.

Reactions were made continuously for one minute, timed with a stop watch. As soon as the minute was over, the experimenter called "Stop. Hands up," stopped the kymograph and let the curtain down over the cats. The child then rested for 60 seconds, without getting down from his stool. Each series consisted of 5 work minutes and 4 rest minutes in the order W—R—W—R etc. As previously stated, one series a day was given for 10 days as nearly consecutive as possible. All of the children, except one who dropped out because of illness, ran through the 10 series.

Instructions were repeated at the beginning of each day's experiment for the first four or five days. One or two of the subjects found it difficult to grasp the idea of the task and, therefore, received special help, on the first day, while the eyes were flashing. After the third day it seemed unnecessary to repeat instructions, so the children were simply given a reminder at the beginning of the first work period on each day following: "You remember what you do, don't you?" During the running of a series, children were not addressed or interrupted unless extreme need arose for encouragement or control.

RESULTS

The subjects were divided into two groups, A and B. Group A consists of the 4 children with whom the experiment was started. These subjects reacted to the initial rate or stimulation (4 flashes per light per minute) throughout all ten of the series. As has been stated, this rate proved too slow to hold the interest of the children after learning was established. The conditions of the experiment were, therefore, altered by doubling the original number of light flashes per minute beginning with Series IV.

This change in procedure made it necessary to discard the first four sets of records. Inspection of these data shows that actual performance was probably not much affected by rate of stimulation within the given range. Curves of efficiency and variability take about the same form for the four "slow" children as they do for the youngsters in the main experimental group. The kymograph reading, however, can give no picture of the difficulty we had in holding these children to their task. The dominant idea, see—light—push—button, was apparently not strong enough to span the relatively long waits between flashes. It seemed to fade about the middle of the interval leaving the youngsters receptive to all sorts of other stimuli,—to which they certainly responded. Every tack in the Cat box, every crack in the floor, every screw in the telegraph keys became astoundingly important, so that only the most extraordinary vigilance on the part of the experimenter kept the apparatus intact and the subjects present either in body or in spirit.

Our experience with Group A made it very clear to us that too little stimulation can be as disintegrating and destructive in a learning situation as too much,—a finding which probably has considerable significance. No other conclusions were drawn from this part of the experiment, which does not enter further into the discussion of results.

Group B consists of the 16 children who performed the experiment according to revised technique. The data obtained from these records have been analyzed statistically with reference to the three main lines of interest suggested in the statement of the general problem. The discussion which follows is based entirely upon the work of this group.

Measurement of attention

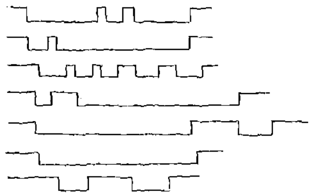
The value of the conclusions reached in this part of the study depends upon two things:

1. The validity of the assumption that attention means integration, and
2. The accuracy of the method of scoring devised.

The more carefully we observed the children's behavior the more inclined we were to feel that we had a good working hypothesis. Without exception, the subjects making the most successful adaptation to the experimental situation presented the classic picture of attentive behavior. The body was still, held firmly but not rigidly in a position of readiness. The hands rested lightly on the supports, fingers flexed for the forward thrust, each nicely in line with its key. The eyes were fixed intently on a point midway between the two cats on a

level with the lights. One felt, in the total organism, a complete readiness and a singleness of purpose. The light flashed, was perceived. The child responded instantly, following the pattern which he had set, but calling into play the special set of processes any one of these irrelevant bits of activity meant that a sub-group of processes was truant from the main constellation, and responding to other, more or less unrelated, stimuli.

Obviously, in this experimental situation, a measure of attention would



Record of Response	Description	Symbol	Score
	Right	R	20
	Incomplete	Ri	15
	Reduplicated	Rd	10
	Held	Rh	5
	Delayed	D	0
	Omitted	O	-20
	Errors	E	-20

FIG. 1. EVALUATION OF RESPONSES

SERIES I MINUTE A	LIGHTS							
	1		2		3		4	
	Type	Raw Score	Type	Raw Score	Type	Raw Score	Type	Raw Score
Responses	R R Rd R	20 20 10 20	Rd Rd Ri D	10 10 15 0	E E Rd R Rd Ri E	−20 −20 10 20 10 15 −20	E R Ri D Rd	−20 20 15 0 10
Totals.......		70		35		−5		25

FIG. 2. SAMPLE DATA SHEET

involved in selecting the particular finger to press the proper key.

Any changes in the nature of the response were on the negative side and resulted in a less than perfect performance. Talking, swinging the feet, lifting the hands, twisting the head,— be a graded scale with a maximum score for a perfect response and a series of decreasing values for imperfect responses, errors and omissions.

The method of scoring was not decided upon until after the first few sets of records had been critically

studied. This analysis showed that the children were making 7 distinct types of response:

1. Responses entirely correct.
2. Responses which began correctly but were held too long, i.e. after the flash was over.
3. Responses which were incomplete. In these the keys were pressed only part way down, or were pressed and released just as the stimulus light went out.
4. Responses which were correct, but repeated.
5. Delayed responses.
6. Wrong responses.
7. No response at all.

These recorded differences corresponded closely with the observed differences in the attentive behavior of the children. Each less than perfect response meant that the child had failed to be aware of, or to adjust to, one or more significant factors in the total situation,—had failed to this extent to integrate all relevant processes,—to attend.

A numerical equivalent was arbitrarily given to each of these 7 kinds of reaction. For convenience in scoring we adopted a scale with steps of 5, ranging from plus to minus 20. Fig. 1 shows each type of response as it inscribed itself upon the record, together with the symbol used to designate it and the value assigned.

The records were marked on the original kymograph paper and then transferred to data sheets. These data sheets were arranged in such a way that one could see at a glance how many and what sorts of responses were made to each one of the stimulus lights during each one of the working minutes. See fig. 2. By adding the figures in the separate columns, we were able to express numerically the total value of the reactions made to any one of the lights, and thus, by inference, measure the amount of attention which each light received.

Entries on the data sheets were, of course, raw scores, and did not in any way indicate the percentage of rightness of individual responses. Raw scores were, therefore, converted into true (T) scores. These true scores are quotients obtained by dividing the raw score for a given interval by the highest attainable score for the same length of time. To get these perfect scores, we multiplied the actual number of stimulations occurring in the given interval by 20.

Illustration: During Minute A, Series I, the lights flashed 16 times. A perfect response would be worth 16 × 20, or 320 points. Actually the responses were 20 in number,—5 perfect, 3 incomplete, 6 reduplicated, 2 delayed, 4 errors. The total value of these (See fig. 3) is 125. T score for Minute A, Series I, is 125 divided by 320, or .39.

The highest possible T score was 1.00; the lowest possible, an indeterminate minus depending on the amount of deduction for errors.

Basic calculations were made as follows:

1. T scores for each light for: (a) Each working minute, (b) Each series.

2. Mean T scores for: (a) Each light for each minute, (b) All lights for each minute, (c) All lights for each series.

3. Mean variations for : (a) Each light for each minute, (b) All lights for each minute, (c) All lights for each series.

There is a source of error in the scor-

in other words, that performance was fairly even. A high mean variation, on the other hand, meant extreme differences in T scores from minute to minute during the series. Inspection of these variability curves indicated that in every case there was a marked reduction in variability during the progress of the experiment.

Composite curves of efficiency and variability show clearly the rise in the first and the drop in the second for the group as a whole. See fig. 4.

With these general trends in mind we analyzed the data in further detail, considering:

1. The nature of progress in relation to certain key series for both efficiency and variability.

2. Relationships implicit in the data.

3. Unitary responses to individual stimuli (the separate lights). These were studied from the standpoint of: (a) Distribution of attention to the several lights in the field, and (b) The influence of position of stimuli upon the stimulus value of individual lights.

There were, because of the nature of the test situation, 3 critical series in each full set of reactions,—I, IV, and X. These represented the attack, adaptation to the changed rate of stimulation, and the finish. Was X uniformly better than I? Was there a break at IV? Where were the best scores made? What was the range of initial mean scores, final mean scores, best mean scores? What was the range of scores for initial, final and lowest mean variability? At what point was variability reduced to its lowest terms? We made some headway in all of these directions.

TABLE 2

Mean T scores for key series

NAME OF CHILD	SERIES			
	I	IV	X	Best
Ada	−1.95	−.21	.28	.37
Bertha	− .01	−.38	.10	.14
Bruce	.51	−.06	.52	.54
Christine	.42	−.25	.14	.14
Deborah	.19	.28	.83	.83
Dolly	.46	.00	.61	.61
Edith	− .66	−.54	−.47	−.47
Esther	− .60	.20	.27	.42
Harold	−1.25	−.31	−.07	−.07
Jessie	− .73	−.67	−.56	−.56
John	− .98	−.53	−.57	−.41
Laura	− .03	−.38	.40	.42
Martin	−1.66	−.68	−.79	−.68
Peter	− .23	−.45	−.20	−.19
Robert	−1.61	−.91	−.44	−.32
Spencer	− .16	−.35	.53	.53
Range for each series	−1.95 to .51	−.91 to .38	−.79 to .83	−.68 to .83

TABLE 3

Mean variations in T scores for key series

NAME OF CHILD	SERIES I	SERIES IV	SERIES X	SERIES Best
Ada	.46	.09	.05	.05
Bertha	.06	.21	.12	.05
Bruce	.17	.17	.10	.10
Christine	.12	.16	.13	.10
Deborah	.15	.12	.06	.06
Dolly	.19	.15	.15	.15
Edith	.23	.19	.09	.07
Esther	.48	.19	.20	.04
Harold	.41	.06	.12	.06
Jessie	.37	.19	.13	.11
John	.28	.08	.21	.08
Laura	.23	.06	.04	.04
Martin	.38	.19	.11	.09
Peter	.23	.06	.08	.06
Robert	.29	.15	.23	.05
Spencer	.31	.10	.05	.05
Range for each series	.48 to .06	.21 to .06	.23 to .04	.15 to .04

TABLE 4

Best scores for efficiency and variability in relation to the series in which they occur

NAME OF CHILD	EFFICIENCY: Best score	EFFICIENCY: Series in which this occurs	VARIABILITY: Best score	VARIABILITY: Series in which this occurs
Ada	.37	9	.05	10
Bertha	.14	7	.05	9
Bruce	.54	8	.10	10
Christine	.14	10	.10	7
Deborah	.83	10	.06	10
Dolly	.61	10	.15	4
Edith	−.47	10	.07	9
Esther	.42	9	.04	8
Harold	−.07	10	.06	4
Jessie	−.56	10	.11	9
John	−.41	7	.08	4
Laura	.42	7	.04	10
Martin	−.68	4	.09	9
Peter	−.19	8	.06	4
Robert	−.32	9	.05	7
Spencer	.53	10	.05	10

TABLE 5

Distribution of best scores according to series

SERIES	EFFICIENCY		VARIABILITY	
	Number of best scores	Percentage	Number of best scores	Percentage
4	1	.06	4	.25
5	0	.00	0	.00
6	0	.00	0	.00
7	3	.19	2	.13
8	2	.12	1	.06
9	3	.19	4	.25
10	7	.44	5	.31
Totals....	16	1.00	16	1.00

were higher than initial T scores for the same subjects. The rise, however, was by no means regular. Special analysis of the first three series for all records shows that 10 of the curves rose rapidly, 1 remained on a plateau, and 5 went decidedly down.

b. There was a decided break for every child between Series III and IV. This did not mean the same thing in every case, however. Every one of the 10 subjects who gained rapidly for the first three days was set back when the rate was changed. The child who had heretofore made no progress, began to gain. Of the 5 children who had been losing ground, 1 continued on down hill, but 4 made significantly better scores on the fourth day than on the third.

c. There were two kinds of high

TABLE 6

Changes in mean scores for efficiency and variability with change in rate of stimulation

NAME OF CHILD	MEAN T SCORES				MEAN VARIATION			
	Series III	Series IV	Gain	Loss	Series III	Series IV	Gain	Loss
Ada	.45	−.21		1	.18	.09	1	
Bertha	.07	−.38		1	.13	.21		1
Bruce	.78	−.06		1	.07	.17		1
Christine	.25	−.25		1	.19	.16	1	
Deborah	.85	.28		1	.10	.12		1
Dolly	.73	.00		1	.09	.15		1
Edith	−1.65	−.54	1		.55	.19	1	
Esther	.38	.20		1	.17	.19		1
Harold	− .12	−.31		1	.17	.06	1	
Jessie	− .74	−.67	1		.37	.19	1	
John	−1.60	−.53	1		1.12	.08	1	
Laura	.32	−.38		1	.17	.06	1	
Martin	−2.31	−.68	1		.38	.19	1	
Peter	.18	−.45		1	.11	.06	1	
Robert	−2.44	−.91	1		1.22	.15	1	
Spencer	.43	−.35		1	.16	.10	1	
Total number gained or lost			5	11			11	5
Percentage			31%	69%			69%	31%

1. Analysis of the Nature of Progress. (Tables 2 to 6 inclusive.)

The general conclusions which were reached when the data were analyzed from this point of view may be stated as follows:

a. In all instances, final T scores

scores. There was the high mark obtained within the first three series by the child who adapted immediately to the task and took full advantage of the slow rate of stimulation to run up a good score. More important than tributed themselves throughout the several series from IV to X, but tended to appear toward the end. Seven, or 44 per cent, of them occurred in Series X. This probably indicates that most of the children were still improving in

TABLE 7

Correlations for each child between efficiency and variability, based on rank order comparisons of daily mean T scores and daily mean variations

NAME OF CHILD	r	P.E.
Ada	.32	±.20
Bertha	.29	±.20
Bruce	.81	±.08
Christine	.15	±.22
Deborah	.64	±.13
Dolly	.21	±.21
Edith	.70	±.11
Esther	.82	±.07
Harold	−.03	±.22
Jessie	.84	±.07
John	.82	±.07
Laura	.47	±.17
Martin	.50	±.17
Peter	.18	±.22
Robert	.71	±.11
Spencer	.38	±.19
Mean	.49 ±.17	
Range	−.03 ±.22 to .84 ±.07	

TABLE 8

Intercorrelations between mean T scores for key series

SERIES COMPARED	r	P.E.
Initial and Final	.64	±.10
Initial and Best	.66	±.10
Best and Final	.98	±.01

TABLE 9

Intercorrelations between mean variability scores for key series

SERIES COMPARED	r	P.E.
Initial and Final	.09	±.18
Initial and Best	−.31	±.16
Best and Final	.39	±.15

this was the highest T score obtained on the relatively long stretch between IV and X after the rate of stimulation was doubled. It is this latter which will be regarded as the best score and referred to as such throughout the rest of this paper. These best scores dis- ability to attend the given situation when the experiment ended.

d. The range of mean scores in each group was fairly wide.

Initial scores ranged from −1.95 to .51
Final scores ranged from − .79 to .83
Best scores ranged from − .68 to .83

The minus scores are chiefly due to omissions and errors. Improvement means reduction of error and increasing accuracy in response.

e. The range in variability of score is as striking as the range in mean scores.

Initial mean variations range from .48 to .06
Final mean variations range from .23 to .04
Lowest mean variations range from .15 to .04

TABLE 10

Intercorrelations between scores for efficiency and variability

MEASURES COMPARED	r	P.E.
Initial mean T score and initial mean variability..	.81	±.06
Final mean T score and final mean variability....	.40	±.15
Highest mean T score and lowest mean variability..	.24	±.17

TABLE 11

Correlations between I.Q.s and mean T scores for key series

MEASURES COMPARED	r	P.E.
I.Q. and initial mean T score....................	.30	±.16
I.Q. and final mean T score..	.60	±.11
I.Q. and best mean T score..	.60	±.11

f. A study of the variability in score from series to series proved particularly interesting. Two children had records showing the lowest mean variation in Series III. In all other cases, the lowest mean variation was attained in a later series. These low variations were found somewhat earlier in the learning than the high scores for efficiency. Four of them are in Series IV, and only 5, or 31 per cent, in Series X. Evidently the steadying down in performance came before the high point in achievement was reached.

2. Study of Relationships Implicit in the Data (tables 7 to 12 inclusive). Certain questions of relationship next arose, suggested by the data already accumulated. Was the child who gave the best performance in the beginning the child who finally achieved the best score, the highest final score? Was the child with the highest I.Q. the child who made the best initial score, the best score, the highest final score? With regard to variability, was the child who showed least variation in the first series the child who showed least at the end? Was there any discoverable connection between initial scores and best, i.e. lowest, scores for variability? What, in general, was the relation between efficiency in total performance and variability? Which is the better basis for predicting how a child of this age will follow through a task,—his I.Q. or the quality of his first attack upon the problem?

TABLE 12

Correlations between I.Q.s and mean variabilities for key series

MEASURES COMPARED	r	P.E.
I.Q. and initial mean variability..................	.12	±.17
I.Q. and final mean variability....................	.09	±.18
I.Q. and lowest mean variability..................	.36	±.15

Because of the small number of cases used in this study, any correlations calculated were bound to have large probable errors. Certain coefficients were worked out by Pearson's rank

order method, however,—r $= 1 - \frac{6\Sigma d^2}{N(N^2 - 1)}$; P.E. $= .7063 \frac{1-r^2}{\sqrt{N}}$. These measures are gross, but probably accurate enough to show tendencies. The following coefficients of correlation were obtained:

a. The correlation between efficiency of performance and variability for each individual child. In 8, or 50 per cent, of the cases this correlation was .50 or over; being .80 or above in 4 instances. For at least half of the children, then, the best performances tended to be the most even.

b. Correlations between initial, final and best scores for performance. These show, in general, a tendency for the child who is successful on the first series to be successful throughout. There is a very high correlation, .98 ± .01 between final score and best score, indicating that the last series was usually the best.

c. Correlations between initial, final, and lowest scores for mean variability. These show a negligible amount of coincidence. The child whose approach is erratic may pull himself together and later be quite steady. Correlation between scores for final variability and least variability is low, .39 ± .15, which suggests that the steadying down comes somewhere before the last series.

d. Correlations between group scores for efficiency and variability. These give a high positive correlation, .81 ± .06, between initial efficiency and initial variability, but nothing else significant. Just as, in individual cases, the best series tended to be the most even, so here for the group, the best initial performances tended to show the least variability. As the other correlations would lead one to suppose, there is a very slight relationship between final performance and final variability. One is somewhat at a loss, however, to explain the very low correlation, .24 ± .17, between the very best scores and the lowest variabilities.

e. Correlations between I.Q. and efficiency, and between I.Q. and variability. These would seem to indicate that the I.Q. correlates fairly well with either best or final performances (these correlate with each other), but not appreciably with any of the other measures. A high I.Q. on this age level may be a good reason for expecting ultimate success with this sort of problem, but does not guarantee a good first performance. Conclusions are tentative because of the relative unreliability of these early I.Q.'s.

3. Detailed Analysis of Unitary Responses. The nature of the experimental set-up was peculiarly favorable for this part of the study. Report of the analysis follows:

a. Distribution of attention to disparate stimuli. It will be remembered that adequate response to this test situation involved a distribution of attention to 4 stimulus lights, and that the kymograph recorded the reactions to these separately. On the data sheets these lights were numbered 1, 2, 3, and 4 beginning with the light on the left. As previously explained, the score for each response to each flash was entered on the data sheet under the number corresponding to that light. In the scores for each work minute for each individual position we thus had a numerical measure

of distribution of attention which seemed fairly satisfactory. If light 1 were found to have a consistently higher score than light 3, one would probably be justified in assuming that light 1 received a greater share of attention. If on the other hand, all 4 lights received approximately equal scores, for a given interval, one would assume that atention during that interval was more or less evenly distributed over the whole field.

In order to obtain a measure of the variability in response to separate lights we proceeded as follows: We calculated the mean score per light per minute, and the mean variation of these scores. We then computed the average of the mean variations for each day. These averages we called coefficients of distribution,—C.D. These averages are the plotting points on charts which represent the "distributability" of each child for each day. (Table 13.) Inspection of these charts shows that in every single case there is a marked difference between the first and last coefficient, which must mean that an original tendency to concentrate on one or two lights alone has been more or less overcome. The curves have the same general shape for all 16 subjects. In 15 of the cases we find a more or less abrupt drop through the first four days to a level upon which the rest of the plotting points fluctuate. Learning apparently takes place fairly rapidly.

Since the first three days of each experiment were days of adjustment for the children, behavior was probably influenced by many extraneous factors which later ceased to operate. At any rate, the raw curves fluctuate ex-

TABLE 13

Averages of the daily mean variations in scores for distribution of attention to each light for each minute

NAME OF CHILD	SERIES									
	1	2	3	4	5	6	7	8	9	10
Ada	.73	.37	.29	.20	.25	.28	.21	.25	.23	.15
Bertha	.35	.28	.24	.18	.22	.15	.15	.15	.16	.16
Bruce	.19	.13	.14	.22	.16	.12	.16	.15	.10	.16
Christine	.28	.20	.29	.22	.11	.19	.17	.14	.27	.21
Deborah	.30	.18	.07	.14	.15	.09	.12	.11	.13	.19
Dolly	.33	.25	.16	.28	.18	.21	.19	.12	.18	.16
Edith	.21	.39	.52	.24	.15	.28	.23	.18	.23	.22
Esther	.69	.36	.26	.24	.22	.15	.15	.15	.12	.12
Harold	.47	.38	.24	.30	.17	.19	.22	.18	.20	.13
Jessie		.42	.63	.22	.16	.23	.19	.19	.18	.25
John	.43	.49	.47	.18	.39	.27	.24	.32	.40	.39
Laura	.32	.24	.42	.21	.17	.20	.18	.16	.21	.11
Martin	.73	.47	.78	.20	.32	.22	.22	.24	.31	.13
Peter	.29	.34	.29	.13	.16	.16	.20	.21	.12	.18
Robert	.64	.72	1.01	.45	.26	.21	.24	.22	.20	.25
Spencer	.34	.26	.18	.20	.25	.16	.16	.13	.22	.09

tremely during this period. In order, therefore, to be as fair as possible in measuring the difference between initial and final distribution of attention to this problem, we averaged the first coefficients of each series, and the last three for purposes of comparison. Obtaining, for each child, the actual difference and the percentage of difference between these derived coefficients (table 14), we find that (1) The percentage of reduction ranges from 7 per cent to 72 per cent, and that (2) The average drop in variability in score for separate lights is 45 per cent.

TABLE 14

Comparison of initial and final variability in distribution of attention to the four lights. C.D. = coefficient of distribution. See text

NAME OF CHILD	INITIAL C.D.	FINAL C.D.	GAIN	PERCENTAGE OF GAIN
Ada	.46	.21	.25	.54
Bertha	.29	.16	.13	.45
Bruce	.15	.14	.01	.07
Christine	.26	.21	.05	.19
Deborah	.19	.11	.08	.42
Dolly	.25	.15	.10	.40
Edith	.38	.21	.17	.45
Esther	.41	.13	.28	.68
Harold	.35	.19	.16	.45
Jessie*	.53*	.21	.32	.60
John	.46	.37	.09	.20
Laura	.33	.16	.17	.51
Martin	.66	.23	.43	.65
Peter	.30	.17	.13	.43
Robert	.79	.22	.57	.72
Spencer	.26	.15	.11	.42

* Based on 9 Series, (II to X inclusive).

In order to relate this finding to other measures already obtained the following correlations were calculated, the rank order method again being used.

1. The correlation, in the case of each individual child, between measures of distribution of attention and (a) Measures of efficiency, (b) Measures of variability.

These do not give conclusive results. The correlations between efficiency and ability to distribute attention range from .93 ± .03 to −.81 ± .08, average, roughly .49. In 7 of the cases the correlation is .50 or over. (Table 15.)

The correlations between variability in performance and ability to distribute attention range from .90 ± .04 to −.27 ± .21. The average is approximately .74. Here with 8 of the children the correlation is .50 or over. See table 15.

2. Correlations, for the group, between measures of efficiency and distribution of attention. These are all positive, and fairly high, (table 16.)

3. Correlations, for the group, between measures of variability and distribution of attention. Two of these are positive and one not significant (table 17). The correlation between the scores for mean variability on the initial series, and the initial coefficients of distribution is fairly high, .71 ±.09. There is no correlation, for the group, between the scores for low-

TABLE 15

Correlations for each child between daily mean variation in distribution of attention and daily mean measures of efficiency and variability

NAME OF CHILD	CORRELATIONS BETWEEN DAILY MEAN T SCORES AND DAILY MEAN VARIATIONS IN DISTRIBUTION OF ATTENTION		CORRELATIONS BETWEEN DAILY MEAN VARIATIONS IN T SCORE AND DAILY MEAN VARIATIONS IN DISTRIBUTION OF ATTENTION	
	r	P.E.	r	P.E.
Ada	.38	±.19	.90	±.04
Bertha	.22	±.21	−.25	±.21
Bruce	.35	±.20	.47	±.17
Christine	−.38	±.19	−.27	±.21
Deborah	.55	±.16	.12	±.22
Dolly	.26	±.21	.44	±.18
Edith	.66	±.13	.67	±.12
Esther	.64	±.13	.60	±.14
Harold	.15	±.22	.43	±.18
Jessie*	.25	±.22	.50	±.16
John	.93	±.03	.90	±.04
Laura	.36	±.19	.51	±.16
Martin	.78	±.09	.45	±.16
Peter	−.81	±.08	.04	±.22
Robert	.83	±.07	.75	±.10
Spencer	.56	±.15	.59	±.15

*Based on 9 Series only, II to X inclusive.

TABLE 16

Correlations between daily mean variations in distribution of attention and mean T score for key series

MEASURES COMPARED	r	P.E.
Initial mean distribution of attention and initial mean T scores	.78	±.13
Final mean distribution of attention and final mean T scores	.54	±.13
Best mean distribution of attention and best mean T scores	.77	±.07

TABLE 17

Correlations between daily mean variations in distribution of attention and mean variations in T scores for key series

MEASURES COMPARED	r	P.E.
Initial mean distribution of attention and initial variability	.71	±.09
Final mean distribution of attention and final variability	.48	±.13
Best mean distribution of attention and lowest variability	.08	±.17

est variability and most even distribution. This may be because it is possible to give well distributed attention to a total stimulus pattern for one testing minute, and yet be essentially inattentive to the whole situation the next, which would mean a high variability for the series even though the coefficient of distribution were very low.

4. Correlations between I.Q. and ability to distribute attention are all low. Here again the significance of the findings is not clear because of the well known unreliability of the I.Q. in these early age ranges, (table 18).

TABLE 18

Correlations between I.Q. and ability to distribute attention

MEASURES COMPARED	r	P.E.
I.Q. and initial mean distribution of attention....	.07	±.18
I.Q. and final mean distribution of attention......	.05	±.17
I.Q. and best mean distribution of attention......	.42	±.14

Evidently it is possible to learn to distribute attention fairly evenly over a number of elements in a given field. It also seems to be true that whatever the I.Q. measures in these particular children does not help them much in learning to adjust well to a complication of stimuli. It would be extremely interesting to know what capacities do facilitate such an adaptation and what limits the extent to which this can be accomplished.

b. Influence of position of stimuli upon attention. In order to determine whether or not the position of any given light influenced its stimulus value, we analyzed the reactions to the various flashes in terms of theoretical probability. Did any particular light tend to receive the highest scores, i.e. the largest number of correct responses? To determine this we ranked each light for each work minute according to excellence of score, rank 1 being the highest score obtained during one work minute by any one light. We then constructed a 16-fold table in which we entered each light once for every response according to rank and number, (table 19). The theoretical probability that any given light will appear in any one of the four ranks is the same for each, since the number of items (responses) is sufficiently large (3328). This theoretical frequency was calculated and entered in the cells, (figures in italics). The comparison with the theoretical fre-

TABLE 19

Contingency table showing the relation between the theoretical and observed frequency with which each light occupied a given rank according to excellence of score. See text

RANK	POSITION OF LIGHT			
	1	2	3	4
1	*208* 223.5	*208* 147.5	*208* 222	*208* 239
2	*208* 223	*208* 215	*208* 198	*208* 196
3	*208* 213	*208* 209	*208* 218.5	*208* 191.5
4	*208* 172.5	*208* 260.5	*208* 193.5	*208* 205.5

Top figure (italics) in each cell = theoretical frequency. Lower figure = observed frequency.

quency of the actual number of times that the given stimulus light actually occupied a given rank shows that responses to individual lights follow fairly closely a chance distribution. The coefficient of contingency has not been calculated for the entire table since inspection of separate cell contingencies seems to show that the position of the stimulus light does not have a determining influence in directing the attention of these young children in this experimental situation. There is a slight tendency to favor the right, and a somewhat more pronounced tendency for the second light from the left to be neglected.

Individual differences

Throughout the experiment, individual differences in the behavior of the children were striking. In so far as these could be analyzed they seemed to be due to fundamental differences in personality development or to emotional upsets resulting from experiences outside of the laboratory. Previous training in obedience, coöperation and self-control helped far more than a high I.Q. in meeting this new situation. Two children who seemed especially well taught in these respects showed remarkably even distribution of attention on the first testing day although one I.Q. was 83 and the other 145. Another child with an I.Q. of 145 scattered extremely during the first three series and learned very slowly to attend to the total stimulus pattern.

The emotional upsets were profoundly disturbing to the experiment, but in most cases we did not know our children well enough to be sure of the causes. In some instances, however, we knew enough about the home situations to be able to guess at the reasons for a child's disorganization. The ups and downs in all of Christine's curves are a more or less accurate picture of a prolonged excitement over the coming of a new baby. The abrupt rise on her chart, showing very poor control of attention on the eighth day, coincides with the arrival of the infant. Bertha is a child who comes from a home in which there was constant friction between the parents. She was a sensitive child who was rapidly becoming neurotic in her attempt to adjust to the stresses and strains of a chaotic environment. Constant jarring kept the child so stirred that she was never able to make a satisfactory adjustment to the experiment. Harold was a totally undisciplined little boy who ruled his family by temper tantrums. Thwarting in any way demoralized his powers of self-organization and affected the quality of his attention to a marked degree.

One important factor in the handling of these children did not receive adequate consideration. We had no good check on physical condition, and were not able to arrange for one. We, therefore, do not know to what extent possible organic disturbances may have influenced response. It is true that the one child who was obviously ill with a cold during most of his experiment made very satisfactory progress, both in efficiency of total performance and in learning to control distribution of attention.

We were interested to discover that, even with these young children, the intensity of the overt behaviour was

not a reliable indication of the real extent of the emotional disturbance. In one or two instances an erratic record on the kymograph was our first clue to a profound distress of spirit which later expressed itself in bitter tears.

One hesitates to generalize on the basis of so little real evidence, yet it seems clear, from these observations,

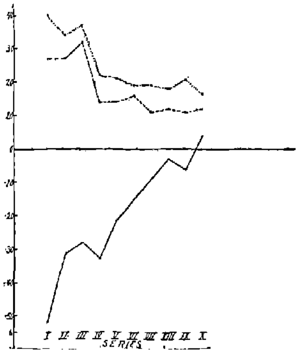


FIG. 4. CHART SHOWING COMPOSITE CURVES FOR EFFICIENCY, VARIABILITY AND POWER TO DISTRIBUTE ATTENTION

.... Mean Scores for Distribution of Attention (Distributability); — — — Mean Variations (Variability); ——— Mean T Scores (Efficiency).

that a condition of emotional stability is essential for the development and control of attention.

SUMMARY AND CONCLUSIONS

In this study of attention in five year old children we have defined attention as integration, or integrated state. On the basis of this definition, we have assumed that one is measuring attention if one measures adequacy of response. We have here attempted to measure such adequacy in a situation involving continuous discriminative reaction to four stimulus lights.

We have found that:

1. All children tested improved in their ability to perform the task required.

2. This improvement was closely accompanied by reduction in variability of performance.

TABLE 20

Recapitulation of mean scores for efficiency, variability, and power to distribute attention

SERIES	MEAN T SCORES	DAILY MEAN VARIATION IN T SCORES	DAILY MEAN VARIATIONS IN DISTRIBUTION OF ATTENTION
1	−.52	.27	.40
2	−.31	.27	.34
3	−.28	.32	.37
4	−.33	.14	.22
5	−.21	.14	.21
6	−.16	.16	.19
7	−.09	.11	.19
8	−.03	.14	.18
9	−.06	.12	.21
10	+.04	.12	.17

3. Both variability and level of final achievement appear to be functions of the ability to distribute attention over a field, an ability which is, in itself, a point of individual difference and subject to modification.

4. There is no evidence that position is a determinant of attention. The picture is, rather, one of original fixation on one or more details (in this case, one of the four positions) with a gradual apprehension and control of all the elements involved.

5. A condition of emotional stability appears to be essential for success-

ful response in all situations requiring concentration of attention.

Fig. 4 (table 20) gives a complete summary of the whole experiment. It shows, in a striking way, the convergence of the three curves representing efficiency, variability and power to distribute attention. One cannot escape the conclusion that the three have a functional relationship.

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The Acquisition of Motor Skill in Young Children

II. The Influence of Specific and of General Practice on Motor Skill[1]

J. Allan Hicks

A RECENT paper (3) gave a report of a study of some aspects of the development of motor coordination in young children as measured by the moving target test. From the analysis of the data on this test it was found that both a practice and a control group made gains in average scores from the initial to the final tests, but that the difference in gains was not significant. These results were interpreted as an indication that the improvement in motor ability found in both groups probably resulted primarily from the operation of common factors such as structural maturation and general practice which had a direct bearing on the specific skill. On the moving target test investigation 60 children, including 12 three-year-olds, 18 four-year-olds, 18 five-year-olds, and 12 six-year-olds were divided into 2 groups of 30 children each so that the average scores and the standard deviations of the scores were equal for the 2 groups. Both groups were also made comparable in age and sex distributions. One group—the practice group—repeated the test once a week for eight weeks, while the other—the control group—was not tested during this period. At the end of this period both groups repeated the test twice on successive weeks. In no case was a child instructed in techniques of improving skill in throwing.

The present paper is a report of a study carried on parallel with the moving target investigation which also bears upon the problem of the relation of specific practice to the increase of motor skill. Three motor tests—the strength (2), the perforation (1), and the tracing path (4), were each given twice to the same children used in the target investigation—once during the period when the initial target test was given and again when the final target test was given. In order to make the changes in scores on the 4 tests comparable the time between the first and last tests was kept as nearly equal as possible for each child. The average lapse of time for the practice group on the four tests was 83 days and for the control 82 days.

The object in giving the strength, perforation and tracing path tests was

[1] This study was completed while the author was a scholar in child development of the National Research Council at the Iowa Child Welfare Research Station.

to compare the gains of children on motor tests on which they were not practiced with their gains on the target test on which half were given specific practice and half were not. As score units on the different tests are not directly comparable the results were evaluated by expressing the gain as a multiple of the standard deviation on the initial test.

As the strength, perforation and tracing path tests have been described in detail by the investigators designing them, Blackhurst (2), Baldwin and Stecher (1) and Wellman (4), they will be but briefly summarized in this paper.

STRENGTH TEST

The strength test was devised to measure strength of arm and shoulder pull. The child is required to lift weights weighing $15\frac{3}{4}$ pounds a set from the floor by pulling downward on a rope and pully arrangement which gives a mechanical advantage of two to one. The child first pulls with his right arm alone, then with his left alone and finally with both arms at the same time on separate sets of weights. This procedure is repeated 3 times. The number of centimeters the child lifts the weights from the floor is recorded as the score.

PERFORATION TEST

The perforation test measures the motor coördination required to punch out small broken circles on a piece of ordinary bond paper containing 50 such broken circles arranged in checker board fashion. The paper is held taut between 2 frames clamped to the table so that the child can readily punch out the holes with a small stick. The score is the average number of holes punched out in 3 trials of 1 minute each.

TRACING PATH

The child is required to draw a line with a pencil between 2 printed lines 25 cm. long and 5 mm. apart at one end and 1 mm. apart at the other. In the present study four of the directions reported by Wellman were used and for the preferred hand only. The sequence of directions repeated three times for each test was: (1) vertical and downward, (2) horizontal and to the right, (3) horizontal and to the left, (4) diagonal and downward to the right. The score on this test is the percent of the child's line which is within the tracing path.

RESULTS

Table 1 gives the average scores on the initial and final tests and the gains in average scores for the moving target, strength, perforation and tracing path tests. The group designated as the practice group for each test is the group of 30 children who were given weekly practice on the target test. As previously explained, the gains are given both in score units and as multiples of the standard deviation on the first test. The table also gives the difference in gains of the practice and control groups in score units for each of the four tests with the statistical reliability of the difference.

An explanation of each column in this table, as numbered, follows:

1. Group: The results for the practice group are given in comparison with the results for the control group for the different tests. The group designated as the practice group on the

strength, perforation and tracing path tests is the group given weekly practice only on the target test. The composite results of the children in both groups are also given.

2. Number: The number of children in each group. The records are for the same children on the different tests.

3. Mean 2: The average score made by each group on the final test. For the moving target test the score of an individual was the average of 10 throws at the target. The score for each throw was obtained by subtracting from 25 the number of inches from the center of the target that the ball struck. For the strength test an individual's score was the average pull in centimeters of 3 trials with the right arm alone; for the perforation test, the average number of holes punched in 3 successive trials; and for the tracing path test, the average percent of the child's line within the path on 3 trials on each of the four directions previously mentioned.

4. Mean 1: The same as column 3 except the data are for the initial tests in each case.

5. Gain: The gain in score units obtained by subtracting mean 1 from mean 2 for each group. For example, these results show for the target test that on the average the 60 children threw 1.6 inches closer to the center on the final test than on the initial test. On the strength test the children pulled up the weights 3.5 centimeters farther; on the perforation test they punched out 7.2 more holes; and on the tracing path they marked out of the paths 1.1 percent more.

6. S. D. Dist. 1: The standard deviation of the distribution of scores on the first test, or the measure of digression of scores from mean 1.

7. Gain ÷ S. D. Dist. 1: Column 5 divided by column 6. This gives the gain of each group on each test in terms of the standard deviation on the initial test. Assuming comparable distributions of talent for the groups under comparison, this gives a measure which is independent of different score units and so directly comparable for different tests.

8. S. D. of gain: The standard deviation of the gain given in column 5 as obtained by use of the formula for correlated measures,

$$\gamma \text{ Diff.} = \sqrt{\gamma^2 \text{ Av. } 1 + \gamma^2 \text{ Av. } 2 - 2r12\, \gamma \text{ Av. } 1\, \gamma \text{ Av. } 2}$$

The correlation coefficients between initial and final scores of three to six-year-old children which were used to compute the standard deviations of gains were as follows:

TEST	GROUP	NUMBER OF CHILDREN	COEFFICIENT
Moving target	Practice	30	.87 ± .03
Moving target	Control	30	.70 ± .06
Moving target	Combined	60	.70 ± .04
Strength	Practice	30	.91 ± .02
Strength	Control	30	.90 ± .02
Strength	Combined	60	.91 ± .02
Perforation	Practice	30	.78 ± .05
Perforation	Control	30	.60 ± .08
Perforation	Combined	60	.66 ± .05
Tracing path	Practice	30	.87 ± .03
Tracing path	Control	30	.93 ± .02
Tracing path	Combined	60	.91 ± .02

9. Gain ÷ S. D. of gain: Column 5 divided by column 8. This gives a di-

rect comparison of the size of the gain relative to its standard deviation. If this quotient is approximately 3.0, the gain may usually be considered statistically significant.

10. Diff. in gains: The gross gain of the practice group (column 5) minus the gross gain of the control group (column 5). This is the difference in gains for the 2 groups in score units.

11. S. D. of diff. in gains: The standard deviation of the difference obtained in column 10, computed by use of the formula,

sigma difference in gains =

$$\sqrt{\gamma^2 \text{ gain } 1 + \gamma^2 \text{ gain } 2}$$

The sigmas of gains in column 8 were used.

12. Diff. in gain ÷ S. D. of diff: Column 10 divided by column 11. This is a measure of the statistical reliability of the difference in gains between the practice and control groups.

When table 1 is examined in detail the following points seem of most significance:

TABLE 1

Increase in skill on motor tests with and without specific practice

(1) GROUP	(2) NUMBER	(3) MEAN 2	(4) MEAN 1	(5) GAIN	(6) S.D. DIST. 1	(7) GAIN / S.D. DIST. 1	(8) S.D. OF GAIN	(9) GAIN / S.D. OF GAIN	(10) DIFF. IN GAINS	(11) S.D. OF DIFF. IN GAINS	(12) DIFF. IN GAIN / S.D. OF DIFF.
Moving target test											
Practice	30	13.6	11.7	1.9	5.7	0.33	0.33	3.2			
Control	30	13.0	11.7	1.3	5.6	0.23	0.73	1.8	0.6	0.95	0.63
All	60	13.3	11.7	1.6	5.6	0.29	0.52	3.1			
Strength test											
Practice	30	27.7	24.5	3.2	12.5	0.26	0.94	3.4			
Control	30	24.2	20.4	3.8	10.6	0.36	0.86	4.4	−0.6	1.27	−0.47
All	60	25.9	22.4	3.5	11.8	0.30	0.64	5.5			
Perforation test											
Practice	30	38.7	33.3	5.4	7.9	0.68	1.04	5.2			
Control	30	36.8	28.0	8.8	7.6	1.16	1.50	5.9	−3.4	1.83	−1.86
All	60	37.8	30.6	7.2	8.2	0.88	0.98	7.3			
Tracing path test											
Practice	30	76.5	78.6	−2.1	17.6	−0.12	1.57	−1.3			
Control	30	73.8	74.0	−0.2	21.7	−0.01	1.48	−0.1	−1.9	2.15	−0.88
All	60	75.2	76.3	−1.1	19.9	−0.06	1.10	−1.0			

1. The means are lower for the control group on both the initial and final test on the moving target. The girls in the five-year control group made especially low scores on the strength, perforation and tracing path tests.

2. The standard deviations for the

practice and control groups (column 6) do not vary greatly in any of the tests, showing that the distributions of measures in the 2 groups were similar.

3. The gains expressed in units of the standard deviations on the first test show that the control group made larger gains than the practice group on the strength and perforation tests. Both groups made losses on the tracing path, that of the control group being smaller.

When total groups are considered the gain for the moving target test is 0.29 sigmas; strength test 0.30; perforation test 0.88; tracing path -0.06.

4. The statistical significance of the gains of 60 children (columns 8 and 9) is greatest for the perforation test, the gain being 7.3 times the sigma. It is next greatest for the strength test, the gain being 5.5 times the sigma; then for the moving target with 3.1; and finally for the tracing path with a negative 1.0. Thus the groups as a whole made significant gains in 3 of the 4 motor tests. For the small loss on the tracing path test the writer has no explanation.

5. Columns 10, 11 and 12 show that the differences in gains of the practice and control groups are not statistically significant on any of the 4 tests. The gain of the practice group on the moving target test was 0.6 ± 0.95 more than the gain of the control group. The gain of the practice group was 0.6 ± 1.27 less than the gain of the control group on the strength test; 3.4 ± 1.83 less on the perforation test; and the loss 1.9 ± 2.15 more on the tracing path test.

SUMMARY

The present paper reports a parallel study to the moving target test investigation on the effects of specific practice on the increase of motor skill. The 60 children in the target study were also given the strength, perforation and tracing path tests once during the period when the initial target tests were given, and again when the final target tests were given approximately three months later.

On the strength and perforation tests the increases in skill without specific practice as shown by the tests were comparable to increases on the target test either with or without specific practice; while on the tracing test slight losses were found. No important difference was found on any of the four tests between the gains of the group that was given weekly practice on the target test and the gains of the control group.

These results support the conclusions of the former paper that improvement in skill may result from factors other than specific practice, such as the influence of structural maturation and of general practice. Probably no one doubts that specific practice must at times be given to young children, but for what skills and under what conditions is as yet largely undetermined. The implication of the experimental findings of this and of the previous paper is that factors other than specific practice may account for much of the learning of young children.

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The Roentgenographic Appraisement of Skeletal Differentiation[1]

T. Wingate Todd

THE SIGNIFICANCE OF A QUALITATIVE STUDY OF GROWTH

IT IS a well established fact that different parts of the body differentiate and mature at different periods of the life span. We know, for example, that the auditory ossicles and labyrinth are fully matured at birth, that the eyeballs and brain have almost reached adult size by five years, that the thymus and tonsils are at their greatest development and activity in childhood. The list might be indefinitely extended although along such lines we should but make generalizations without that directness of evaluation to which the method of study lends itself. It has been our good fortune during the past eighteen years to assemble a collection of human skeletons from known individuals for each of which it has been possible to secure the necessary data for a comprehensive study of growth and maturation, and of age changes in the remainder of the life span so far as these are set forth in the bones. This series has now reached the comparatively large total of eighteen hundred individuals including more than two hundred children and young people. In addition the roentgenographic study of a test sample of over one thousand children gives us opportunity to check the observations made both by the X-ray and by dissection or maceration on our skeletons. Hence it is my object in this communication to direct attention to the principles of differentiation and maturation in the skeleton with special reference to those areas which we have studied most intensively during the past four years, namely the knee, the hand, and the elbow.

In a previous article I have discussed the problem of comparative youth and have given briefly our conclusions that although the chronological record varies with the order, family or genus of mammal chosen for investigation, the time relationships are sufficiently precise within the selected group to make comparisons possible of sequence and rate of maturation (1). I have also, in another paper, presented the principles of epiphysial differentiation and union which hold good for all parts of the maturing skeleton (2). It is now possible to inquire more deeply into the specific features of maturation and the time-linkages involved.

Since the ossified parts of the living skeleton alone are radio-opaque, it is

[1] This is the third of a series of studies on Comparative Youth from the Hamann Museum, Laboratory of Anatomy, Western Reserve University, Cleveland, Ohio, prepared for the White House Conference.

practicable to study simply the bony differentiation. The cartilaginous skeleton remains a sealed question. In the dead this difference is at least partially resolved for both cartilage and muscle become radio-opaque from coagulation in embalming. The possibility of dissection finally removes all difficulties of interpretation. A combined study of skeletons and living children then opens up great opportunities for enlarging our knowledge and understanding of the changes undergone by the skeleton during the period before adulthood is attained.

It is essential, in the first place, to recognize that an epiphysis is not to be construed as a bony cap. It is a cartilaginous structure which ossifies completely, partially or not at all. If it ossifies in part only as at the symphysis pubis, the lateral end of the clavicle and the upper and lower surfaces of the vertebral bodies, the remaining cartilage is absorbed but the bony fragments of epiphysis and the adjacent surface of the shaft undergo the same stages in differentiation and maturation as if the epiphysial ossification were complete.

My colleague Doctor N. W. Ingalls has shown in a very thorough investigation of the growing femur that the form and proportions of the articular ends, characteristic of the adult, are already exhibited in the cartilaginous ends at birth (3). And Graves has demonstrated the preformation of convex, straight and concave types of the vertebral border of the scapula in the foetal cartilaginous state (4). In the epiphysial unit then, growth merely increases dimensions.

For the shaft there is another story: proportions change with growth as well as dimensions. So long as we rely upon dimensions of the skeleton in general or of any unit in particular as our standard of measurement and time-linkage, as we have been accustomed to do, so long will we be baffled or hampered in our estimates. I do not mean to infer that dimensional measurements, quantitative though they be, ought to be discarded, ignored or minimized in value. It is important to realize that quantitative measures involving growth are subject to influences which do not affect the qualitative standards of differentiation. As a rule, if the organism is handicapped, the disability shows itself in dimensional stunting rather than in retardation of differentiation. There are far more people of small stature in the world than there are people of inhibited maturity. Whether we are tall or short we tend to progress toward maturity at the same rate. Edith Boyd has recently shown that an excusable error in dimensional measurement may easily reach the value equivalent to six months' growth (5). In laying stress upon the advantages of recording progress in the qualitative terms of differentiation we seek merely to eliminate one disturbing factor from our calculations and to add another check upon the accuracy of our determinations.

GENERAL METHOD OF STUDY

In addition to a rather full study of bodily dimensions, including weight, and an examination of muscular power each child of our sample group, numbering approximately one thou-

sand, was roentgenographed. The roentgenograms were antero-posterior and lateral of hand, elbow, knee and foot, with antero-posterior only of hip and shoulder. The total exposure is less than that to which a patient is subjected in a regular hospital examination. Finding that we never encountered even a slight malaise or disturbance we added a lateral of the skull to the later examinations.

The children returned for re-examination at intervals of several months so that in the course of two years we had frequently two and less often three studies of each child.

In order to forfend any obvious interference with the ease of establishing standards of age-relationship in bony differentiation we divided our living children series into groups by sex and color and investigated each group separately. Long experience of research on the skeleton led us to suspect that the white children would be far less irregular in differentiation than the negroes and that the boys would show greater uniformity than the girls. The sequel proved our hypothesis correct. We made no effort to distinguish between different nationalities or localities of birth and upbringing though we later found certain small divergencies apparently linked, probably indirectly, with these factors.

We then still further subdivided our sex and stock groups into series by age into units of six months and checked the birth records. Utilizing those roentgenographic records only of children the register of whose birth we had actually seen on the City Hall records, we arranged the roentgenograms in order of differentiation, working upon one of our six areas at a time, and chose that child as our standard for the period nearest to mean value in roentgenographic differentiation, in stature and in weight. Comparing our sequential standards we could then interpolate the remaining roentgenographic records. Having thus drawn up an atlas of differentiation we discarded all our previous work and, upon the basis of our roentgenographic atlas, gave each child an age valuation in years and months. This technique, first carried out for male whites, was repeated upon female whites, male negroes, female negroes and lastly upon undernourished children from the Children's Fresh Air Camp and the Cleveland Nutrition Clinic. As, one by one, our skeletal areas were studied in completion we made a comparison of the age valuations for each on every child and checked these against chronological age, height age, and weight age. The results were so gratifying that we immediately put the method into practice in the numerous child examinations which the city requests of us and we have no reason to regret this step.

The determinations in each stage of the work have not depended upon the observations of a single individual. Between four and eight trained observers have independently gone through every detail of the investigation. The number of workers employed has naturally depended upon funds available and willingness to cooperate. We have allowed no record to pass without at least four independent judgments and one common consultation and discussion thereafter.

So assiduous a study is not completed speedily. For four years we have been continuously at work and so far have completed our survey of knee, hand and elbow. Shoulder, hip and foot are in various stages of progress and at least another year's study will be needed before these are ready for publication.

Confining our attention to the areas already thoroughly studied it is possible to survey briefly the principles of differential epiphysial maturation and their time relationships.

THE PROBLEM OF INITIAL OSSIFICATION

Numerous studies have been made of the inception of ossification in carpal bones and upon them have been based attempts at definition of time-linkage. That there is value in this method there is no doubt. Without seeking to present an adequate survey or bibliography of the work which is largely based upon Pryor's pioneer investigations one might refer to Miss Sawtell's recent work in which she extended the method to include lower end of radius and ulna (6, 7). Doctor Sawtell indeed checked the method against the qualitative study of differential maturation which we have developed and found her results about equally dependable by both methods. But since the children at her disposal greatly diminished in number soon after the date when our method becomes available we take great encouragement from her positive findings even though they seemed to her equivocal.

It should be realized that the individual variability in appearance of ossification of the several carpal bones should not be set down to a "natural" variability until a thorough investigation has been made of possible influences which may affect the date of inception. Perhaps this assumption of natural variability may have been one of the most stultifying conceptions in all work of this character. We have noted evidence in our records of the passage through the system of some devastating influence of temporary character which appears to have held up the progress of maturation and from which the skeleton is in process of recovery. Concerning this we shall have much more to recount at a later date.

In practice we are not concerned with the actual date at which osseous material is first precipitated in any cartilaginous area nor are we inclined to take into account the more or less symmetrical extension of this ossific center until the later stages are reached where final delineation of ultimate outlines is foreshadowed.

Since no epiphyseal ossifications have reached the stage when they can be profitably used as qualitative age determiners until the sixth year of life, at least in boys, we shall commence the account of observations with the fifth birthday.

To avoid confusion by the injection into the problem at this stage of the modifying influences of sex and race, we shall confine the following account to the male white series. It is not an easy task to examine the host of available roentgenograms, bearing all possible features in mind, to evaluate these, identify them on the chosen group of unimpeachable age-record and establish their distribution. If the reader be inclined to cavil at our

results, let him bear in mind that each feature herein described has been searched for by half a dozen different investigators on twelve hundred roentgenograms, an analysis occupying more than three years of steady work. Our simple method of statement is purely in the reader's interest.

Should the reader attempt to use this preliminary account as a guide for age-identification he must be warned that the greatest difficulty will be encountered between seven and nine years, more especially in hand and elbow than in knee. During these years the indicators are peculiarly delicate and hence require more experience and judgment for correct interpretation than at other ages before or after.

After thirteen years and a half we enter upon another phase of epiphysial study. No longer are we dependent upon differentiation of bony outline in the various epiphyses. There now begins the progressive pattern of union which makes much easier the identification of age. We are no longer seeking features of stages I to V inclusive of the maturation of epiphyses. We now look at specific areas for evidence of stages VI to IX (2). Consequently, after thirteen years and six months the dates at which these later stages may be expected alone are mentioned in this account.

PRINCIPLES OF BONY DIFFERENTIATION IN THE KNEE

At the knee we depend almost entirely upon bony differentiation of the epiphyses of femur and tibia for our standards. Since the patella commences to ossify erratically like the carpals and its inception occurs towards the fifth birthday in boys one may rule it out until much later. The upper epiphysis of fibula is of relatively little service until it is almost completely ossified, an event which does not occur until after the twelfth birthday.

Between five and five and a half years there is no great amount of ossification in either femoral or tibial epiphysis. In the femur the ossification scarcely advances beyond the dorsal line of the shaft. The lateral epicondyle shows more ossification than the medial.

The outline of the tibial ossification is much rounded with but a suggestion of the ultimate appearance of 2 condylar surfaces the medial of which shows some condensation into a white line. The backward extension, as in the femur, scarcely reaches the level of the dorsal line of the shaft.

In the following six months ossification of femoral epiphysis projects beyond and tibial ossification reaches the dorsal shaft projection line. Ossification of the medial femoral epicondyle is now progressing more rapidly than in the lateral. Tibial epiphysis ossification shows clear evidence of medial and lateral extensions and the medial condylar face is further etched in. A faint haze springs up along adjacent shaft surfaces of both bones.

Between six and six and a half years ossification has progressed considerably in both epiphyses. The lateral femoral epicondyle casts a shadow almost as far as the lateral angle of the shaft but medial epicondylar ossification lags behind but has a ragged

appearance. The tibial epiphysis begins to show indications of a lateral condylar surface. Both adjacent shaft surfaces maintain their slight haziness.

In the next six months again rapid progress in ossification has taken place in both epiphyses. The medial femoral epicondyle is still ragged. Its ossification however now almost reaches the line through the adductor tubercle. The limiting angles of ossification nearest the shaft on both epiphyses are somewhat squared. The shaft haze remains.

Between seven and seven and a half years the shaft hazes have become quite widespread from the surface. In both epiphyses ossification has extended beyond the bevelled contours of the shaft. In femur the intercondyloid notch is still shallow and in tibia the lateral condylar surface is a little more clearly indicated.

Six months later this lateral tibial condyle is distinctly foreshadowed. The haze on both shaft surfaces is maintained.

Between eight and eight and a half years the tibial ossification for the lateral tuberosity extends like a long tongue almost as far as the shaft line: both lateral condyle and spines show progress. On the femur the downward extension of medial epicondyle and the intercondyloid notch are both better marked. The shaft-haze begins to diminish.

In the succeeding six months the shaft haze has given place to a white line of delineation and a similar line, maturing during the last few periods, is now complete on the adjacent epiphyseal surface.

Both diaphyso-epiphysial gaps are broad and trumpet-shaped at both extremities.

Between nine and nine and a half years there is but little change from the features of the previous period. The adjacent surfaces of shaft and epiphysis parallel each other more closely and the trumpet-shaped extremities of the gap are encroached upon by an angulation towards the shaft of the bony epiphyses. In addition the lateral tibial condyle shows a building up of its periphery.

In the next six months the medial and lateral margins of the femoral epiphysis lose their rounded outline and begin to take on the adult rugged contours. The intercondyloid notch is also more significantly adult. Squaring of periphery of both tibial condyles proceeds apace.

Between ten and ten and a half years the medial and lateral angles of the shaft surfaces of both bones show an erosion, blunting and even rendering them concave. The trochlear extension of the femoral epiphysis shows a faint upwardly directed beak.

In the following six months the trumpet-shaped extremities of the epiphysial gaps are lost through extension towards the shaft of the bony epiphyses which are clearly now beginning to develop peripheral rims. This is better marked in femur than in tibia. The peripheral contours of both epiphyses take on more definite adult characters.

Between eleven and eleven and a half years the diaphyso-epiphysial gap is distinctly narrowed. This is more easily seen in the tibia because there is less overlap of shadows. The double

contour of the articular surface of patella now comes into being.

In the next six months the tibial spines are clearly developed in bone but have not yet sharp outlines. The epiphysial peripheral margins are almost completely adult in contour and the condylar outlines almost sharp though the bony epiphyses do not as yet fit like caps overlapping the shafts.

Between twelve and twelve and a half years there is no marked change.

In the succeeding six months the trochlear diaphyso-epiphysial gap is filled and the epiphysial peripheries almost cover the shafts.

Between thirteen and thirteen and a half years the tibial tubercle has ossified as a downwardly directed tongue of bone, the tibial spines form sharply outlined minarets and the epiphyses of both bones surround the shaft peripheries as with a claw.

Beyond thirteen years and a half the knee epiphyses are of service only at intervals.

Between fourteen and a half and fifteen years the tibia enters on stage VI with narrowing of the epiphysial gap.

Between fifteen and fifteen and a half years stage VI is apparent in femur and in fibula.

Between sixteen and sixteen and a half years the epiphysial gap in the tibia is so reduced that the roentgenogram is apt to give misleading and fallacious evidence of commencing union but the area has not really yet reached stage VII where union begins.

Only the most careful exmination of the roentgenogram of seventeen to seventeen and a half years will indicate to the experienced observer that union is incomplete in femur, tibia or fibula. The naked bone shows no surface indication of union though it would be an untenable position to hold that nowhere in the depths of the gap is there any fusion, at least in the tibia.

Between eighteen and nineteen years both stage VIII of recent, and stage IX of perfected union are passed through in all 3 bones.

PRINCIPLES OF DIFFERENTIATION IN THE HAND

In the knee the massive epiphyses of femur and tibia carry so much of the information applicable to a study of time-linkage in differentiation that one is apt to overlook, on that account, the significant information to be obtained from the shafts. In the hand however the shafts and epiphyses of the long bones and the bony maturation of the carpals all play their part. Phalanges and ulna are of little value for this investigation. The radius, on the contrary, is of paramount importance. Metacarpals follow close behind the radius. And the carpals also give us very definite information once their apparent vulnerability to retarding influences is recognized and discounted.

Shortly before the sixth birthday the bases of metacarpals II and III foreshadow their adult outline. The saddle-shaped contour of the second is definitely attained although the clear white line which marks its ultimate differentiation does not appear till almost eighteen months later. The bony invasion of radial epiphysis is not far advanced at this stage though an oblique line marking the border be-

tween palmar and distal surfaces is evident.

Between six and six and a half years the epiphyses of metacarpals II and III, sometimes of IV but never of V are so far penetrated by bone that on the roentgenogram they appear as D-shaped shadows with the flat outline next the shaft.

In the succeeding six months the process spreads to the head of metacarpal V and includes IV if this did not appear before.

Between seven and seven and a half years the white line of compacta demarcating the saddle-shaped base of metacarpal II makes its appearance.

In the succeeding six months attention is diverted to the radius for its epiphysis shows ossification of the styloid process. The adjacent surface of shaft presents a billowed outline picked out in the typical thin white line of compacta.

Between eight and eight and a half years the carpus begins to contribute to our study in the white line marking the facet on os capitatum for articulation with metacarpal II.

In the following six months ossification springs up with sudden rapidity in the radial epiphysis extending medially as the "ulnar tongue."

Between nine and nine and a half years the bony heads of metacarpals II, III, IV possess a clearly defined squared outline like those of the adult.

In the next six months a radial extension of ossification occurs in the radial epiphysis in the angle next the shaft.

Between ten and ten and a half years there is often a completion of the adult contour of the medial side of the fifth metacarpal bony head and a billowing of the ulnar shaft. Both features may however appear earlier than this date.

In the following six months the bony outline for the radial aspect of metacarpal heads II, III, IV, V makes its appearance.

Between eleven and eleven and a half years identification of specific characteristics in the hand becomes singularly difficult. There is indeed an expansion of the bony epiphysis of the radius laterally on the side adjacent to the shaft and a sudden development of adult outline in the two multangulars.

In the next six months the ulnar tongue of the radial epiphysis shows indications of the recurvation characteristic of a year later. The bony epiphysis for the first phalanx of the index finger protrudes beyond the line of the shaft on the lateral or radial aspect.

The hand has now reached a stage when it gives but little direct indication of the progress of time. Between twelve and twelve and a half years there is no characteristic feature although it is true that the inclination towards recurvation of the ulnar tongue in claw-like form over the shaft of the radius is strengthened.

In the succeeding six months recurvation of the ulnar tongue has progressed to the form of a small beak which is further developed between thirteen and thirteen and a half years at which date the later phases of preparation for union of epiphyses in phalanges and metacarpals begin to make their appearance.

After thirteen and a half years, as

in the knee, we change our method of analysis and look for stages VI to IX.

Between fourteen and fourteen and a half years the epiphysial gaps in phalanges and metacarpals commence to diminish.

This narrowing continues during the next twelve months and already the terminal phalanges have reached stage VIII, of recent union, soon after fifteen years.

Between fifteen and a half and sixteen years all the phalanges have reached stage IX (perfected union) and the metacarpals are in stage VII (commencing union) if not already in stage VIII. The gaps in radius and ulna now begin to shrink.

After sixteen years the metacarpals have followed the phalanges into perfected union (stage IX) and the roentgenographic shadows of radius and ulna are overlapping so that both diaphyso-epiphysial planes seem broken up though comparison with the naked bones shows that this is not really so.

Even between seventeen and seventeen and a half years however the roentgenogram, carefully studied, will demonstrate the complete patency of both radial and ulnar gaps. A year later these epiphysis have reached the condition of recent union (stage VIII).

PRINCIPLES OF DIFFERENTIATION AT THE ELBOW

The elbow gave us far more trouble than either knee or hand and at first it seemed as though we would be baffled for of all the diaphyso-epiphysial lines that of the capitulum alone appeared to be helpful. Our final identifications are indeed largely influenced by the indications of that area. Radius head is little more than a scale. Olecranon and medial epicondyle have little specific character. Trochlear ossification is very various in type since the amount of humerus developed in this epiphysis is quite erratic. Sometimes there is a sizeable epiphysis: in other individuals it is but a scale smaller than that for the radial head.

Our interpretations of capitulum are greatly strengthened however by differentiation of the adjacent shaft. Hence, in elbow, our observations, unlike those of hand and knee, are just as closely related to shaft as to epiphysis.

Between five and five and a half years there is incomplete ossification in the ends of all 3 shafts. Consequently the roentgenographic shadows appear to indicate imperfect formation The actual skeletal formation is, of course, complete but, being largely cartilage, is not radio-opaque.

The ulna shadow shows a shallow greater sigmoid fossa of which the coronary beak is not at all well marked so that it is seen with difficulty on the antero-posterior view and scarcely projects at all on either medial or lateral side of the shadow. The olecranon process shows but the faintest indication of a billowing. It is indeed a mere ripple confined to the shaft surface of which the postero-superior area is not yet completely ossified.

On the humerus the capitular epiphysis is considerably ossified but has an irregular margin facing the shaft surface on which can be seen a faint

ripple of billowing. There is only slight angularity between the shaft surfaces which support medial epicondyle and trochlea respectively.

There is no ripple as yet on the surface of the radial shaft.

Six months later the coronoid beak is visible both medially and laterally. The ossification in postero-superior area of olecranon and rippling of subepiphysial shaft surface of olecranon are both better marked. The radius shaft and capitular surface of humerus both now show distinct rippling and the shaft angle between medial epicondyle and trochlea is better defined. It must be realised however that there are pronounced individual differences in the degree of ripple and often it is scarcely visible.

Between six and six and a half years the features of the previous period become intensified. The bony olecranon is more massive and squarer in outline on the lateral roentgenogram. The ossific nodule in the humeral capitulum begins to show a saddle-shaped outline. It is true that there is ossification in the epiphyses of radial head and medial epicondyle of humerus and that the date of appearance of these centers is more uniform in elbow than in hand. Nevertheless we shall make but incidental reference to such precipitations as we are by no means convinced of the reliability of their age relationship.

During the following six months there are no specific characteristics. There is merely extension of the features demonstrated in the previous period.

Between seven and seven and a half years the ossification center in the capitular epiphysis throws out a bony tongue towards the trochlea. This tongue was suggested just after the sixth birthday but at that earlier date the shaft angle between surfaces supporting medial epicondyle and trochlea was not nearly so advanced as it is at this time.

In the succeeding six months bony delineation has reached the surface of the cartilage between medial epicondyle and trochlea although the outline is not yet as sharp as it will eventually be. There is also an extension of rippling or light billowing from capitular shaft surface on to that for the trochlea. The capitular epiphysis ossification begins to spread backwards erratically.

Between eight and eight and a half years the trochlear ossification is extended and the beak of shaft between trochlea and medial epicondyle is further delineated. The backward extension of capitular epiphysial ossification is still quite erratic.

In the following six months the outline of humeral shaft supporting the medial epicondyle becomes distinctly concave. Both in that epiphysis and in the capitulum there is distinct ossific extension.

Between nine and nine and a half years no fresh features are developed though progress can be estimated by comparison with the provisional atlas of stages.

In the succeeding six months the distal humeral shaft shows distinct growth so that the capitulum seems mounted on a pedestal which is particularly developing on its lateral aspect. The supporting surface for medial epicondyle begins to show rippling.

Between ten and ten and a half years the building out of the lateral area in humeral shaft continues while the ossification of the capitulum overlying it is also extended to approach the lateral margin of the shaft. The elbow makes little progress about this time.

Six months later the capitular ossification develops a proximally directed beak at its lateral extremity. This is projected like a claw shaft-wards and precedes the bevelling of the outer angle of the humerus. Erratic ossification begins in the trochlea and olecranon.

Between eleven and elven and a half years there is progress in ossification of trochlea and olecranon but one can claim only as characteristics of the period, an increasing angulation at distal lateral area of humeral shaft, of the capitular epiphysis in the same region, and of the proximal though not yet the distal extremity of the ossific nodule for medial epicondyle. As an age indicator the elbow is already becoming less useful.

In the next six months the shaft outlines beneath capitulum and trochlea become more uniform in slope. This does not necessarily mean that the capitular plane is built up to that of the trochlea: it may still be behind but the general inclination is almost identical on both. The capitular ossification projects backwards like the tail of a comma and there is an increasing parallelism in the adjacent surfaces of shaft and epiphysis. If the olecranon center has hitherto failed to appear it is present now.

Between twelve and thirteen years the several beaks and angulations already mentioned continue their differentiation. In the earlier six months the diaphyso-epiphysial plane under the capitulum becomes sigmoid in the antero-posterior roentgenogram and in the latter six months the capitular beak projects along the lateral aspect of the shaft.

Between thirteen and thirteen and a half years the sub-capitular plane begins to narrow and, in this respect, leaps ahead of all the others at the elbow. Thereafter we are concerned with the epiphysial closure pattern rather than a progress of ossific differentiation.

Already at fourteen to fourteen and a half years there may be commencing union (stage VII) of the distal epiphysis of the humerus, trochlear and capitular ossifications having fused. The union is perfected during the following six months which is marked also by shrinkage in the gap between the radius and its head but not in that between humeral shaft and medial epicondyle. Not only is the olecranon gap reduced but union has commenced.

Between fifteen and fifteen and a half years union has commenced in the diaphyso-epiphysial junction of the radial head and the gap beneath the medial epicondyle is reduced. Olecranon is in the stage of recent union (VIII) and in distal humeral epiphysis fusion is perfected.

After the sixteenth birthday fusion is complete in all elbow epiphyses and the area passes out of the series of age indicators.

Dull and colorless as such an account of epiphysial differentiation must necessarily be, it is important to

realize the stages by which progress in skeletal maturation occurs. The vexed questions of sex and race can find no place in this description which is intended solely as a summary of illustrative material against which roentgenographic records may be checked. To further this object we purpose to draw up detailed accounts with each of which there will be an atlas of carefully reproduced roentgenographic bony outlines to form a seal of definiteness upon our observations.

SUMMARY

1. A qualitative study of growth is called for by the fact that different organs mature each in its own time and manner. Even in such a uniform system as the skeleton, the various parts attain adult characters at very different ages.

2. Although the cartilage precursors of the articular extremities of the various bones differ in size but very little in proportions from the bony extremities of the adult, the penetration of the cartilage by ossification presents so definite a sequence and pattern that it can be utilized as an age indicator.

It is true that disturbance, especially of a pathological character, may modify pattern, sequence and date. The ravages accompanying this disturbance can usually be clearly identified.

3. The samples of male white children at our disposal have been used for this purpose upon the hypothesis, now substantiated, that there is less variation resulting from non-pathological influences among them than among females or negroes. In a later paper the problems of sex and race will be discussed.

4. The reader is warned against the assumption of a "natural" variability in the absence of positive evidence.

5. In this study the date of earliest precipitation of bone into the cartilage, whether of carpals or epiphyses, is not valued highly because that stage of differentiation is singularly vulnerable to influences which delay the characteristic features or distort the evidence.

6. The method of epiphysial and diaphysial differentiation is applicable to the skeleton under thirteen and a half years (in the male). Thereafter it is the closure pattern to which attention must be devoted.

7. In the knee the epiphyses of femur and tibia give most of the information but their underlying shafts present some useful data. Patella and fibula are of less account.

8. In the hand lower epiphysis of radius, the metacarpals and their epiphyses and to a less extent carpals, phalanges and ulna enter into the picture. Because of the frequency of disorder in carpal ossification one must not rely upon their bony etching unless the data presented are confirmed by radius and metacarpals.

9. In the elbow capitular epiphysis of humerus and the shaft area underlying it carry most of the data useful for our purpose. The availability of elbow as an age-determinant is much more restricted in time than the knee and hand.

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The Development of Right-handed Skill in the Left-handed Child

JOSEPH E. MORSH

IN TEACHING the older child to use the non-preferred hand one is confronted by three main problems. The "set" due to habit and earlier training must be broken down; the antagonistic prejudices of parents and teachers must be combatted; and a strong attitude of self-motivation must be built up. Of these three problems the last is probably the most important and an attempt at its solution is the chief concern of this article.

The experiment was undertaken to see whether it were possible to take children into the laboratory and without seriously interfering with their everyday activities, form in them a desire to learn to use their non-preferred hands. The fact that they came to the laboratory, without monetary or other inducement, during the period of the experiment showed that their interest was maintained and the results would seem to justify the method employed.

The skill which was to be developed was writing with the right hand. The method was, briefly, to teach writing with the right hand where the left hand had formerly been used exclusively, without directing attention to the act of writing. In other words, the main point in the experiment was to get the attention of the children away from the activity, as much as possible so that they would gradually acquire a new right-handed habit without realizing that a new habit was being formed.

The subjects used for the experiment were two girls whom we shall designate as B and E. E was twelve years old on July 15, 1929, and was a pupil of the eighth grade. B was a fourth grade pupil and was nine on August 22, 1919. B's score with the Stanford Revision of the Binet-Simon test indicated an intelligence quotient of 100 plus, while E's intelligence quotient was 123 plus. With B, Myer's Mental Measure was used as a check, as the Binet-Simon was given when B was tired. It was found, however, that the latter test agreed with the Binet-Simon very closely. It is worth noting that a remarkable correspondence was found between the intelligence quotients obtained from these tests given in the laboratory and those supplied by the teachers in the public school which the girls attend. Both subjects, as shown by these results, are of normal intelligence while E probably has superior intellectual capacity.

The history of left-handedness in the families of both girls is interesting. E's father and paternal grandfather were left-handed. Her maternal uncle was left-handed as a child but was forcibly prevented from using his

left hand and became a very proficient ambidextrous writer. B's maternal aunt and uncle are left-handed.

The experiment began on November 2, 1929 and continued until March 1, 1930, sessions being held weekly until the Christmas holidays and semimonthly after that time. In a general way it may be divided into three parts: first, tests and observations to ascertain some of the abilities of the subjects (especially manual abilities) with the specific aim of finding out the "degree of handedness;" second, preparatory exercises involving varying amounts of manual-visual coördination; and third, exercises for practise in the activity taught, in this case, writing.

DIAGNOSTIC TESTS

The term "left-handed" is used rather loosely in everyday parlance to designate an individual who uses the left hand in performing some major activities. The word left-handed has, however, no absolute value such as, for instance, the word blind. To be blind is to be devoid of eyesight but to be left-handed is not to be devoid of use of the right hand. To say that a person is left-handed, then, is not to convey much scientific information about him unless we are given an idea as to the extent of the left-handedness. Thus there may be vast differences in the manual habits of so-called left-handed individuals. The first part of the experiment, as before mentioned, was designed primarily to find out what was being dealt with in the matter of handedness, that is, just how much left-handed the subjects were. For this purpose 2 kinds of tests were used. The first group consisted of a number of unimanual and bimanual activities most of which involved gross motor coördination, though a few, such as writing, drawing and painting necessitated finer, more precise coördination.

Table 1 indicates the results of the first group of diagnostic tests. It will be noted that while both subjects used their hands in an identical fashion in a majority of the activities they differed materially in some other activities. It would appear from the observation of these common operations that B was more left-handed than E.

TABLE 1
Hand used in major activity

ACTIVITY	E	B
Drawing on paper or blackboard	Left	Left
Ruling lines	Left	Left
Painting	Left	Left
Cutting with scissors	Left	Left
Peeling fruit with knife	Left	Left
Peeling fruit by hand	Left	Left
Buttoning and unbuttoning	Left	Left
Holding tooth-brush	Left	Left
Placing objects on table	Left	Left
Pushing needle	Left	Left
Threading needle	Right	Left
Picking up or carrying objects	Right	Left
Receiving or handing objects	Right	Left
Ironing	Right	Left
Throwing	Right	Left
Wiping and dusting	Either	Left
Using knife, spoon and glass	Right	Left
Using fork (when knife is held)	Left	Right
Combing hair	Both	Both

With both subjects the left thumb is dominant, and a crude test seemed to indicate that the hearing in their left

ears was better than in their right (the watch-tick test was used). Their eyes were tested with Ives Visual Acuity apparatus, a second test to check the results of the first being given. This test indicated quite conclusively that B's left eye was better than her right while the contrary was true of E, her right eye being superior.

Dunlap's steadiness tester was used. Precision and coördination in tracing was also tested, by means of the Johnson coördination test. A complete description and the method of employing this test may be found in Johnson (2).

A summary of the results of these more exact tests is given in table 2. It is interesting to note that E's right hand was considerably stronger than her left. This fact is probably accounted for when it is remembered that she used her right hand in carrying objects. In the simple tapping B was better with her right hand but in the complicated form of the test when she tapped on two plates alternately her left hand was superior. E, however, was consistently left-handed in tapping. The subjects differed, too, in steadi-

TABLE 2

Scores in tests of motor control

TESTS	E		B	
	Right hand	Left hand	Right hand	Left hand
Strength of grip (Best of 3 trials in kgm.)....	22.25	17.75	13.25	16.0
Speed of tapping				
Simple—one plate				
Average of 5 trials, 30 seconds each......	148	155	118.6	115.6
Complicated—two plates				
Average of 2 trials, 30 seconds each......	39–44	51–48	40.5–44	52–43
Totals for each hand....................	83	99	84.5	95
Average of 2 trials, 1 minute each........	90–91	109–109	79–84.5	91–82
Totals for each hand....................	181	118	163.5	173
Steadiness of hand				
Hole 5—contacts.........................			11	10
Hole 4—contacts.........................		8		
Hole 3—contacts.........................	9			
Precision in aiming				
Average error in mm.....................	8.3	10.2	10.3	11.9
Coordination in tracing				
Contacts in simple test..................	0	1	2	0
Contacts in intermediate test.............	9	2	14	5
Contacts in difficult test................	66	35	93	37
Total contacts...........................	75	38	109	42

The second group of tests in this part of the experiment were for the purpose of building up a more complete diagnosis of the extent or "trend" of left-handedness and the capacities of the subjects. Strength of grip, speed of tapping (simple and complicated), steadiness of hand and precision in aiming were all tested with the apparatus and after the manner described by Whipple (4) with the exception that

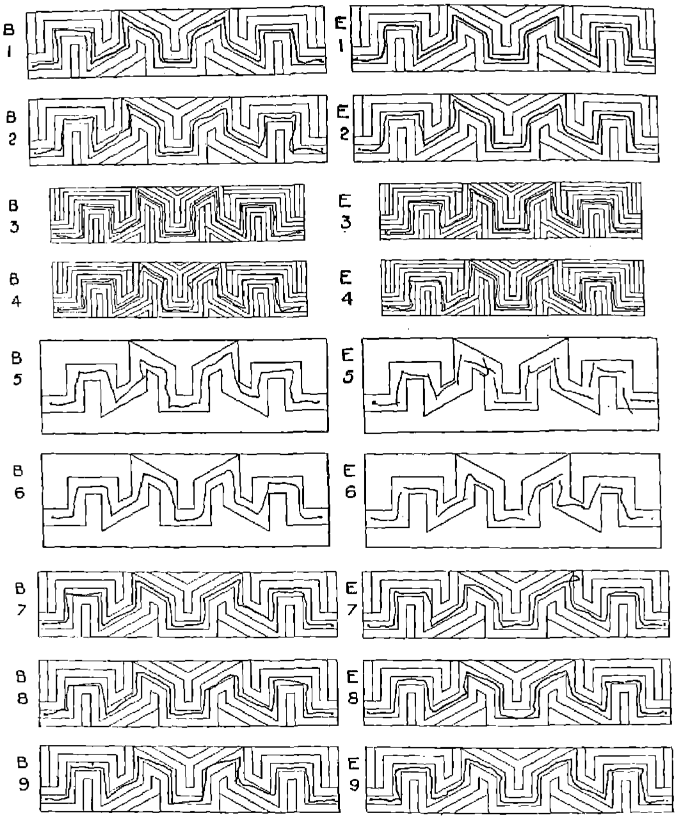

FIG. 1. COÖRDINATION IN TRACING

SUBJECT B				TEST	SUBJECT E			
Number	Date	Hand	Contacts		Number	Date	Hand	Contacts
B1	November 9	L	1	Intermediate	E1	November 9	L	0
B2	November 9	R	2	Intermediate	E2	November 9	R	2
B3	November 9	L	5	Difficult	E3	November 9	L	5
B4	November 9	R	15	Difficult	E4	November 9	R	0
B5	November 16	R	1	Simple	E5	November 16	R	2
B6	November 23	R	0	Simple	E6	November 23	R	0
B7	November 30	R	1	Intermediate	E7	November 30	R	2
B8	December 7	R	3	Intermediate	E8	December 7	R	2
B9	December 14	R	2	Intermediate	E9	December 14	R	0

ness. In this test the score is given for the smallest opening in which less than 12 contacts were made. B had slightly better control with her left than with her right hand while E was much better with her right. In the aiming test both girls showed superior coördination with their right hands.

In the Johnson coördination test both subjects showed a preference for the left hand, B favoring the left more markedly than E. This left-handed preference is clearly indicated in figure 1. B1, B3, E1 and E3 are average strips traced by subjects with their left hands. B2, B4, E2 and E4 show right hand performance on the same day. See legend to figure 1.

TABLE 3

Precision in tracing

DATE	NUMBER AND KIND OF TEST SHEETS	TOTAL CONTACTS			
		B		E	
		Simple	Intermediate	Simple	Intermediate
November 16	5 Simple	3		10	
November 23	5 Simple	1		10	
November 30	3 Simple 2 Intermediate	2	16	1	30
December 7	3 Simple 2 Intermediate	3	42	0	12
December 14	3 Simple 2 Intermediate	1	23	1	6

PREPARATORY EXERCISES

Although, strictly speaking, the first part of the experiment was preparatory as well as diagnostic, the second part had a more direct bearing on the subject in hand, that is, it paved the way for the writing itself.

To teach the fundamental strokes of writing Johnson coördination test blanks were used. The following instructions were given:

"Instead of drawing a continuous line as you did before (these were blanks of the test that had been used in the diagnostic work already mentioned) draw straight strokes but try to avoid touching the black lines. You may lift your pencil slightly from the paper at the end of each stroke and it does not matter if one stroke does not quite meet another one that you have drawn or crosses it a little bit. I shall time you but the time it takes is not so important as to draw nice straight lines and to avoid touching the black lines. Ready. Go!"

Subjects were instructed to hold their pencils in their right hands and use their left hands to steady the paper. No metronome was used.

Table 3 gives a summary of the results of the practise in precision in tracing. The strips from 5 to 9 inclusive in figure 1 are average strips taken from the last sheet done each day. With few exceptions, the contacts steadily decrease and the lines were drawn with greater confidence and rapidity, until the exercise was discontinued on December 14.

As it was thought that some activity involving grosser coördination might assist directly in the development of the finer coördination required

TABLE 4
Scores in target test

DATE	HAND	B	E
November 23	L	82	54
November 23	R	27	93
November 30	R	66	92
December 7	R	70	117
December 14	R	66	117
January 11	R	104	130
January 25	R	88	156
February 1	R	100	108
February 15	R	70	96
February 15	R	84	75
March 1	R	82	146

developed here. It will be remembered from the diagnostic tests that for E the right hand was the preferred hand for throwing while B is left-handed in this activity. The darts were thrown in 5 series of 10 darts each from a distance of 10 feet, the 2 subjects and the experimenter taking turns. As the latter was right-handed, he used his left hand to make the scores somewhat comparable. On the first day the subjects used both hands and thereafter only their right hands. The results as

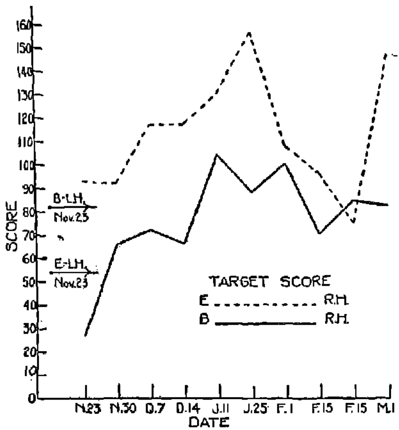

FIG. 2

in writing, as well as indirectly by stimulating subjects' interest in the whole procedure, the target test was used.

The subjects first threw darts on November 23 and continued this activity until the close of the experiment on March 1. An interesting point

may be seen from table 4 are about what we would expect. Figure 2 gives a graphical representation of the target test scores.

The "pièce de resistance" of the whole experiment for the girls was Whipple's star tracing test, as this involved an activity which had never

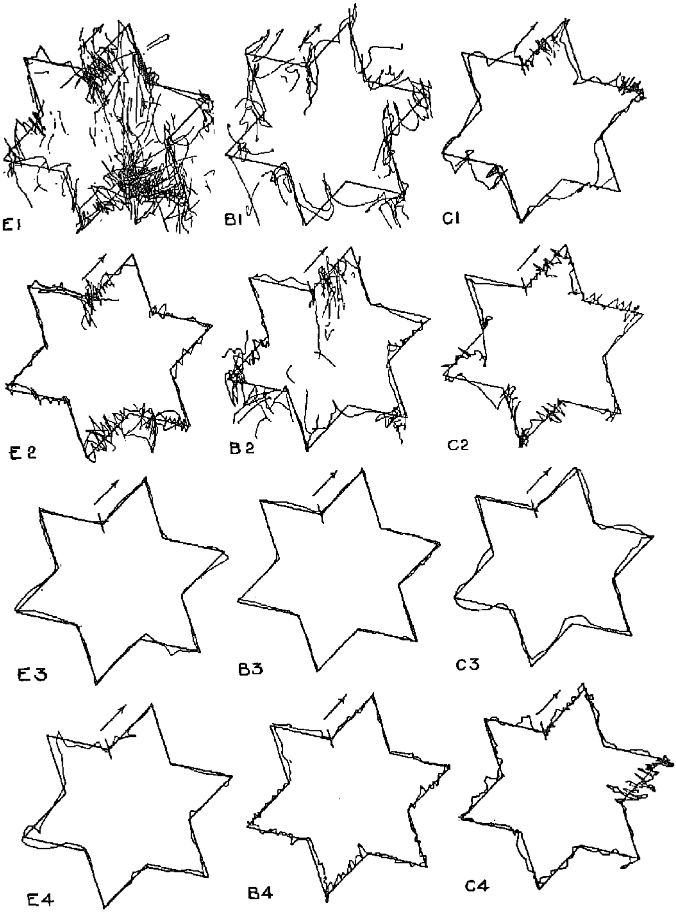

FIG. 3

before been attempted with either hand. When the subject was seated at the table with screen and mirror in position and the star fastened firmly with thumb tacks, the following instructions were given:

"Trace the outline of the star, starting in this direction (indicated by an arrow drawn by the experimenter). Work as rapidly as you can, but try to keep on the line. Don't stop to figure out what you ought to do, but keep your pencil going in some direction, and keep its point on the paper all the time."

The subjects used their right hands to trace all stars except the last one traced on March 1.

On November 9 it took E 11 minutes to trace here first star (E1, fig. 3), making so many errors that it was impossible to compute them by means of the stencil. A diagram of the stencil used in marking the stars and a description of the method of using it is given by Harold E. Israel (1). To quote from the article:

"The stencil is fitted over the star by means of the short guide lines at the points; then the traced outline is followed around from the starting point. Whenever any one of the boundaries of the zones parallel to the outline is crossed, an error is counted (naturally recrossings in the corrective direction are not counted). Thus a deviation beyond the extreme limits of the stencil in either direction from the outline will give an error score of three. Moreover, errors are added for each radial boundary, over one, which the tracing crosses before returning to within the "home" parallel zone. Allowing thus the width of two radial zones for the correction of a wrong motion, this feature penalizes hasty cutting across or carelessness . . . . . Lateral (parallel) zones are 3 mm. in width, and radial zones are 6 degrees."

It will be seen that this rigid system of marking allows a deviation from the outline of only one and one half millimeters less half the width of the pencil line for a traced star scored perfect.

E's second attempt (E2, fig. 3) took 3 minutes 58 seconds and also defied the experimenter's efforts to count the errors. B's first star (B1, fig. 3) took 3 minutes 25 seconds and she made approximately 160 errors. Her second effort (B2, fig. 3) required 2 minutes $57\frac{3}{5}$ seconds. The errors for this star were not computed. As the subjects tired the first day only 2 tracings were made. For 10 different days, at intervals from November 16 to March 1 inclusive, both subjects traced a set of 6 stars each day. E's fastest time for any one star was for her sixty-first star traced in $20\frac{3}{5}$ seconds on March 1 (E3, fig. 3) and her best star, the one with the fewest errors was her forty-first, the last one of the set she traced on January 25. It had 4 errors only. Her best average time for 6 stars was $24\frac{9}{10}$ seconds on March 1 and her lowest average error was $12\frac{5}{10}$ on January 25. The star traced on March 1 with her left hand, the last of the experiment, took $37\frac{2}{5}$ seconds and contained 31 errors (E4, fig. 3) indicating transfer of training but also showing marked superiority for the right hand at this stage in the activity.

B's fastest time for any one star was 26 seconds, this being the time for her twentieth star and the last of the set she traced on November 30. She traced her best star with fewest errors on February 15, this being the last star of the group traced that day and the fifty-sixth of her series. She made only

3 errors on this star. B's best average time was 36 seconds on December 7. (B4, fig. 3) was 1 minute 14⅗ seconds with 66 errors. The best star B

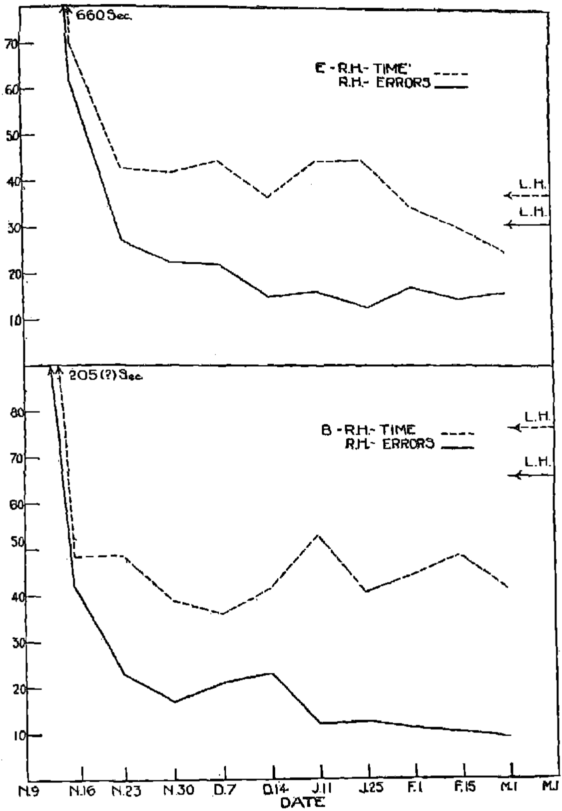

FIG. 4

Her lowest average error was 9 made on March 1. The time for her final star which she traced with her left hand traced on March 1 required 34⅗ seconds and contained 5 errors. It was the second of the group and the fifty-

eighth of the series (B3, fig. 3). This result indicates less transfer of training and even more superiority of right hand over left in this activity than was shown by the other subject. Each subject traced 63 stars in all.

The stars in the right hand column of figure 3 are given for comparison. Cl is the first star traced by an average graduate student; C2 is the second star she traced and C3 is her twelfth. It must be remembered, however, in making comparisons with the stars traced by B and E that these girls were using their non-preferred hands while the graduate student used her preferred hand. C4 is a typical first attempt of an adult as given by Starch (3).

Progress both in eliminating error and in lessening time is clearly indicated by the graphs in figure 4. The ordinates represent the average number of errors (the solid line) or the average time in seconds (dotted line). This graphical representation shows nicely, too, the acquirement of superiority of the right hand over the left hand in time taken and in the number of errors made, the 4 arrows on the right representing the level of preferred hand achievement.

PRACTISE EXERCISES

On January 11, the third part of the experiment was introduced. As emphasized in the earlier part of this paper, some scheme must be divised in order to have the children write with their right hands without calling attention to the writing itself. For this purpose a number of brightly colored flash-cards were made. The cards measured 5 by 7 inches and the subjects chosen were of a very diversified nature to eliminate monotony and hold the girls' interest. Some cards contained words printed in various styles of lettering, others depicted common objects while still others represented people performing some actions, such as sneezing, eating, etc. (see figure 5). The cards were shown for such a very brief space of time that the subjects had to focus their attention upon them in order to see what was pictured. Some of the cards showed several objects and the subjects had difficulty in finding just what the experimenter wished them to see, or rather, pretended to wish them to see. This situation added greatly to the interest created, by introducing an element of competition. The experimenter, of course was not interested in what was written down, but in the writing, the subjects were interested not in the writing but in what they wrote.

The subjects were given the following instructions:

> "I am going to show you a card on which something is written or pictured. I shall let you look at it for one second, then I want you to write down as quickly as possible the word or object you saw. If you see the picture of a person doing something, write what the person is doing. Your writing and spelling doesn't matter, but I want you to use your right hand and write quickly so you won't miss the next card. Ready. Write!"

On the first day 18 cards were exhibited and the subjects wrote with their right hands on lined paper with pencils. E-R2 and B-R2 of figure 6 show the result of this exercise.

On January 25 and again on February 1, 21 new cards were used, the sub-

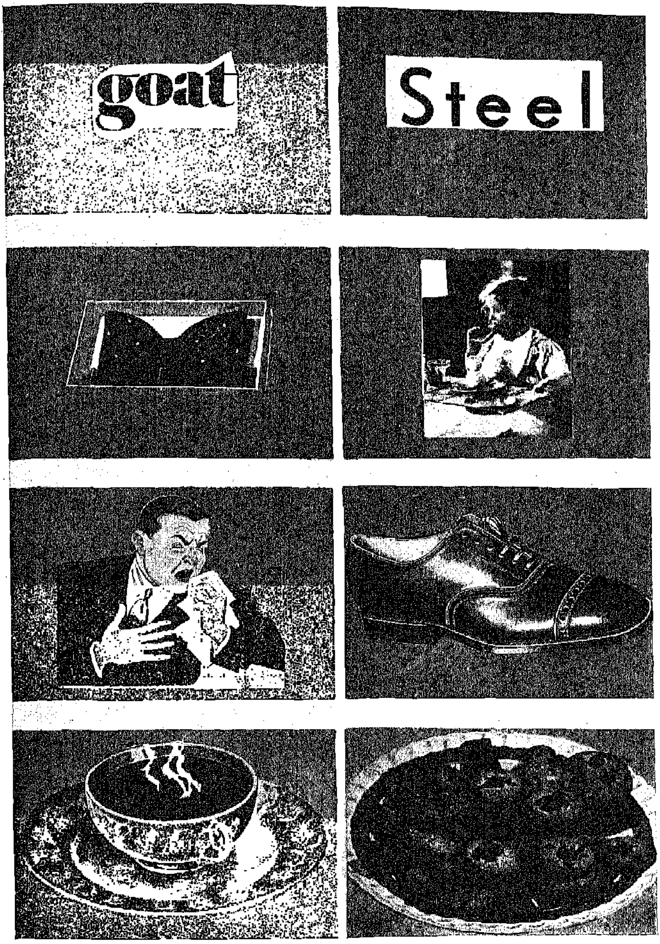

Fig. 5

jects being given the same directions. The cards were held so that they were plainly visible to both subjects. For variation, on February 15 an "opposites" test and a "whole-part" test, each requiring 20 words to be written, were employed. The cue words were dictated by the experimenter. Some of the words written by the girls during these tests are given in figure 6, at E-R3 and B-R3.

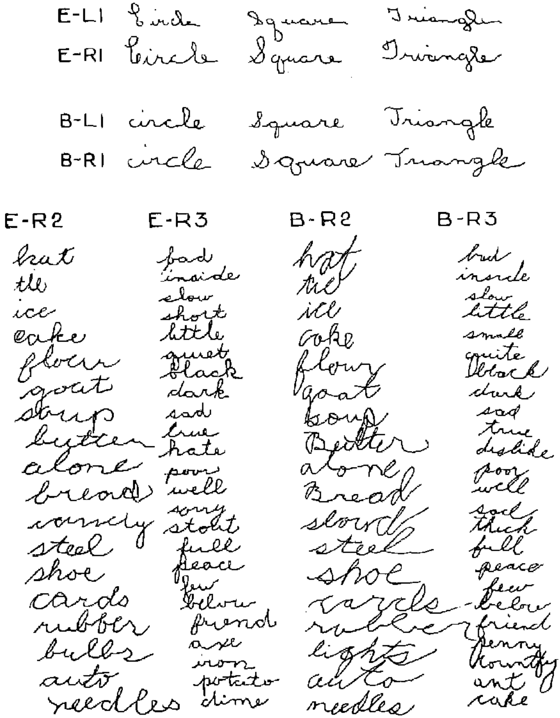

FIG. 6

The remarkable progress in writing

made by the subjects during the experiment is shown in figure 6. E-L1 and B-L1 were written on November 2 when the girls were asked to write as they did in school (with their left hands). On the same date they were asked to write the same words with their right hands, it being stressed that their very best writing with that hand was required. Thus, E-Rl and B-Rl show right hand performance when particular attention was called to the writing. In E-R2, E-R3, B-R2 and B-R3 attention was directed away from the writing. It will be noticed that, at E-R3 and B-R3 the act of writing with the right hand has become practically automatic, the quality of this writing approaching very closely to that done when the whole attention was directed to the writing. The progress in execution from E-R2 to E-R3 and from B-R2 to B-R3 is quite obvious from the figure. All parts of figure 6 were reduced one half.

At this time the teachers who taught the girls in public school were interviewed, and their coöperation sought in giving more frequent practise in writing with the right hand than the experimenter was able to give as he met the subjects only once every two weeks. E's teacher seemed to understand what was required but probably the experimenter's request called undue attention to writing as the teacher noticed for the first time that E frequently made n's like u's though the experimenter had noticed that little idiosyncracy the first time the subject had written her name on the blackboard—to be definite, on November 23. The teacher reprimanded E for her n's. As E had never had any trouble in school previous to this time E's mother was very upset and blamed the experimenter for ruining E's writing with her left hand. She was only pacified when the experimenter showed her some of E's writing that had been done before the experiment commenced in which were found some n's that looked like u's. In a moment of confidence E told the experimenter that her father made that kind of n's, that she liked them, had been making them for a long time. and was going to continue to make them. The experimenter persuaded her to make them the way the teacher wanted them as long as she was in that class.

B's teacher too, was well meaning but her method was confusing and interfered with that of the experiment. She made B write exclusively with her right hand instead of having her write a little each day as the experimenter had suggested. B complained of being tired but the teacher insisted. B complained at home that the teacher was trying to "break" her from writing with her left hand. The parents objected very strenuously to having B "broken" and it required much tact to convince the parents that the experimenter at least was not trying to "break" B of anything. It is to be noted here that even one word such as the word "break" may wreck an experiment that has been going along successfully for months.

The entire procedure outlined in this paper might well be termed an experiment in methodology. The results seem to be on the whole positive

and the method used here gives many indications of solving, partially, at least, the problem of parents and teachers as to what to do with the child who writes with the left hand. If the child is started early enough, if the teacher or parent is tactful and patient, and if the method used is one which minimizes to the lowest degree the importance of the writing done and places sufficient emphasis outside the writing —emphasis which diverts the attention from such things as the awkward "feel" of the pencil in the hand, poor coördination (the hand won't do what you want it to), undeveloped musculature etc.—then, success is assured. The child will probably never forget habits learned with the left hand but he will acquire habits with the right hand, so that performance with that hand will equal or surpass performance of the formerly preferred hand.

Not all of the exercises were continued till the right hand surpassed the performance of the left, but in the star-tracing this was certainly the case, to the surprise of the subjects who could hardly believe that they could trace stars better and faster with their right hands than with their left.

The subjects were observed very closely both by their parents and by the experimenter to note whether there was any interference in their speech. At no time was any stuttering or stammering detected, proving quite conclusively that in some cases manual activities may be learned by the non-preferred hand without causing an emotional upset and consequent speech defects.

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The "Negative Phase" in Relation to the Behavior of Pubescent Girls

E. B. HURLOCK AND S. SENDER[1]

ALTHOUGH a number of books have been written on adolescence and its most outstanding characteristics, little attention has been given to the pre-pubescent and pubescent stages, and even less time has been devoted to a study of them. Recently, however, an increased interest has been shown in this subject, and a few investigations have been made. In Germany and Austria especially, some observational studies have been made of these stages. In the United States, a few studies have been carried out to discover the relationship between physical maturity and certain personality traits of boys and girls.

A summary of these studies will be made under the following headings: (1) meaning of the term Negative Phase; (2) its source of interest; (3) its characteristics; and (4) observations made of the Negative Phase and other studies of physical maturity.

MEANING OF THE TERM, NEGATIVE PHASE

Professor Charlotte Bühler of Vienna has given the name, Negative Phase, to a behavior period of short duration (two to nine months) preceding puberty in boys and girls. This term seemed to her to describe adequately the feelings and behavior of boys and girls during this particular stage of physiological development. The term is justified on the grounds that there appears to be a complete reversal of the usual behavior of the individual, so that conditions which evoked a certain response before this period, now evoke passivity or the opposite of the usual response.

SOURCE OF INTEREST

As has been the case with many psychological investigations of childhood and adolescence, Professor Bühler's attention to the Negative Phase was first attracted by literature. Her source was the diaries written by boys and girls soon after puberty. In the case of the former, the average age was fifteen, and in the case of the latter, fourteen. In these diaries, (4) she was impressed by the constant reference of the writers to their feelings of stress, generally characterized by a desire to withdraw from society, which occurred shortly before puberty, the Negative Phase of development. In the 1929 edition of her book (3) the number of diaries available for her study was 52. From these, she has

[1] The junior author gathered and tabulated the data for this study: the senior assisted in planning the study, in the interpretation of its results, and in writing this report.

generalized concerning the mental and emotional tendencies characteristic of pubescent youth.

CHARACTERISTICS OF THE NEGATIVE PHASE

Because of the large number of characteristics of the Negative Phase, it is desirable to group them in two categories, general and specific.

General characteristics

The following description of the Negative Phase has been translated from Bühler's (4) work based on a study of diaries of boys and girls.

> "An appearance of disinclination; restlessness; a physical and mental uneasiness which finds expression in obstinacy, ferocity, waywardness, and indolence; irritability, melancholia; hatred of self and society as well as hostility toward the latter. During this period their lives are joyless and tiresome; everything is unwelcome and appears evil or bad. Since the process of maturing uses up a good deal of the energy of the person, there results anemia, tiredness, or lassitude. Heightened sensitivity, irritability, restlessness, and the ease with which they can be excited are characteristics of the life of a pubescent."

Hildegard Hetzer, (9) using the results of her observations of a group of girls, states that, "this phase is characterized by passivity and restlessness; loss of interest; desire for isolation, neglect of productive activity; instability; restlessness; loss of skill of performance; withdrawal from friends, parents, and teacher." On the other hand, Lucia Vecerka (17) found that those girls who were orphans, at this time longed for their parents.

Although not referring to this Negative Phase as such, August Kohl (11) describes the feelings, thoughts, and behavior of the pubescent quite similarly to the two preceding accounts. "How many young people groan under the yoke of the new, strange loads which puberty brings them? How much heartache does the attempt cost our half-grownups to compromise, unguided, with the difficult, puzzling facts of a new life-epoch?"

Special characteristics

Some of the special characteristics of the period suggested by different writers are as follows:

Associations. There seems to be a general opinion that the character of associations undergoes a definite change at the time of puberty.

Lucia Vecerka (17) found that prepuberty associations are comradeships which are formed with many and which do not entail purely personal participation. During puberty or soon after, the associations are friendships with one individual only, seeking mutual understanding. There is a return to the comradeship type toward the end of adolescence when the individual joins societies.

Up to thirteen years and five months, there were no general discrimination qualifications for the friendships. After that age, or during puberty, the girls would rather forego friendships than not have the ideal friend. Some of the qualifications for such a friendship are, according to her findings: "the friend must be a lover of truth; must be able to keep still; have strong principles; be intelligent; be understanding and happy; must have no secrets from each other; each must have the courage to tell the other of

es; must love each other."

has noted that in her girls the tendency was to-ecrease in the number of well as toward a change in cter of the associations.

Tupky (12) noticed a similar the character of the associa-bys before and after puberty. anley Furfey (6) pointed out ok on the gang life of boys ages for joining the gang are to fourteen or puberty. At, r puberty, there is a sharp way from participation in ivities.

ship. Hetzer (8) found that he Negative Phase, changes both in the character of and or leadership. A number of linquished their positions as and would have nothing to do e group formerly led by them. f them regained their positions others did not. On the other a few during this period at-d to become leaders. They he girls who never before had aders. The method of attaining id by these girls was radically nt from that of the girls who ed leadership before puberty. as the latter had reached their n through superiority in some l ability, the former attempted to leadership through force, in-ation and coercion.

luence of depraved elements. The r at this age is often of "ill-e" as Hetzer (8) describes her. ugh the girls avoided her before after this phase of development, rtheless, while they were passing ugh the Negative Phase, they grouped themselves about her. At the same time, the girls avoided the person supervising their activities, in whom they previously confided and asked for advice. They grouped and banded only for the purpose of discussing sexual explanations and reading disreputable literature.

Hetzer (8) emphasizes the fact that during this period girls are more liable to allow this influence of disreputable and depraved elements to lead them to actual misdemeanor or sexual delinquency. This emphasis is given additional weight by Charlotte Bühler's (3) confirmation through a survey of the statistics for a ten years' period of a Juvenile Court in Berlin. The statistics revealed that there was a preponderance of sexual delinquencies during the thirteenth year, the time of the Negative Phase.

OBSERVATIONS OF THE NEGATIVE PHASE AND STUDIES OF PHYSIOLOGICAL MATURITY

In 1926, Hetzer (8) who was in charge of an "Hort" (an after-school recreational center) in Vienna where boys and girls came very day after school made an observation of the Negative Phase. She noticed during the year that some girls without apparent cause seemed to change. They became negligent in their work, restless, avoiding former friends, and forming friendships with girls of ill-repute who were generally avoided. Upon closer observation she found that this change in behavior occurred a short time before the establishment of menstruation, when the restlessness and tension, during which no work could be accomplished, ceased and a

return to former positive behavior was made.

A great number of the girls began to write stories, diaries, and letters to imaginary persons or to Miss Hetzer, soon after their emergence from the Negative Phase.

> "The first productive activity at the termination of the negative phase," according to Hetzer, (8) "is litcary. Letters, dramas, plays, diaries, and stories are the vehicles of expression. . . . . The writings of puberty are not the writings of giftedness, but of development. Later, attempts at creative expression may be voluntary, but during puberty, one is driven to expression."

Another Viennese study in regard to the social relations of girls during puberty was made by Lucia Vecerka (17). She had in all 1492 girls ranging in age from eleven to twenty, but used her own classes for intensive study. Specifically, through themeans of a questionnaire, she found that preference for being alone is an outstanding characteristic of puberty.

Mary A. Leal (13) carried out an investigation in the schools of New Britain, Connecticut, to find out the relationship between physiological maturity and certain characteristics of boys and girls. She used the questionnaire method. These questionnaires were given to the teachers who listed the pupils manifesting the various characteristics named, among these were: impatience with restrictions; self-assertion; interest in opposite sex; avoidance of opposite sex; cooperation; gregariousness. The physiological development of each pupil had been ascertained through the use of standard criteria for each of the three levels: pre-pubescent or immature, pubescent or maturing, and post-pubescent or matured development.

She found that all the traits she had listed occurred to a lesser or greater extent in all the three stages of development with the exception of gregariousness which occurred in girls only in the matured stage. The occurrence of some traits, however, were influenced by the type of maturity: early, normal or late. The appearance of other traits seemed conditioned by the I.Q., and still other traits were associated with chronological age.

In girls of high I.Q., impatience with restrictions increased with age, while loyalty to a cause decreased with age. In girls of normal I.Q., the avoidance of the opposite sex increases with age, and loyalty to a principle and clique decreases with age. In girls of low I.Q., on the other hand, the avoidance of the opposite sex decreases with age as well as loyalty to a principle.

In regard to the type of maturing, the early and normal types show interest in the opposite sex, whereas the late maturing avoid the opposite sex. The normal and late also show impatience with restrictions.

PURPOSE OF PRESENT STUDY

The purpose of the present study is two-fold: first, to verify the inevitable occurrence of the Negative Phase in pubescent girls which according to Hetzer (9) "is a first step or concomitant of puberty. Omission of this phase is due to precocity or sexual misdemeanor," and, secondly, to ascertain whether sexual delinquencies occur predominantly during the thirteenth year, the time of the Negative

Phase which Charlotte Bühler (3) found to be the case in her study of cases in a Juvenile Court in Berlin.

To our knowledge there has been no study devoted exclusively to the Negative Phase as a whole with the exception of Miss Hetzer's (8) whose investigation has already been described in detail. This study will, therefore, deal in the main with the results of her observation.

METHODS OF PRESENT STUDY

Questionnaires

A study of records of high school girls was attempted, but after visiting a number of institutions and reading numerous cases, it was found that none kept records of systematic observations of the behavior of the girls; nor did many have recorded the dates of the *establishment of menstruation.* This method of procedure was, therefore, abandoned for that of the questionnaire. Two forms of a questionnaire were prepared: one, to be submitted to girls of the ages between twelve and fourteen; and the other, to be sent to individuals who come in contact with girls of these ages and are in a position to have noticed or to notice the occurrence of the characteristics of the Negative Phase. Unfortunately, the former questionnaire could not be used since no school would permit to be circulated among their girl-pupils a paper containing references to their emotional or mental condition during puberty, lest it cause unnecessary talk among them and direct their attention to an "unhealthy subject."

Five hundred questionnaires of the second form were circulated (1) among Junior High School advisors or principals who took charge of behavior problem girls, and who would, therefore, come in contact with girls under the influence of the Negative Phase; (2) among Junior High School physical training teachers who, through the periodic health examinations, are informed of the physiological development of the girls and at the same time are able to notice the appearance of many of the Negative Phase traits; as: passivity, coöperation, and leadership, etc.; (3) among matrons in charge of homes, settlement houses and institutions; and (4) among school teachers. In order that the reports should not be restricted to any one economic or social class the questionnaries were distributed in different parts of New York City to get samplings from different social and economic groups.

The questionnaires used in this study were constructed from points taken from Miss Hetzer's (8) results of her observations on the Negative Phase. Copies of the questionnaires are given on page 330.

Court cases

In addition to the questionnaire method, court cases were studied in order to see: first, how many of the girls brought to court had recently established their menstruation; and, secondly, to find out whether the largest number of sexual delinquencies occurred during the thirteenth year, time of the Negative Phase as Charlotte Bühler (3) found in her survey. These cases, numbering 142, were read at the Mental Clinic of the Children's Court of the City of New York at 137 East 22d Street, with the permission

QUESTIONNAIRE (For Teachers)

Instructions: Please check the answers.

Have you noticed any of the following changes in behavior of girls about 12–14, a short time before menstruation was established?

In what per cent of girls do you judge these changes to occur?

1. Loss of interest in: school......, work......, play......, home......, friends......
2. Desire to be alone? Yes...... No......
3. Neglect of creative activity, such as playing piano, painting, etc. Yes...... No......
4. Restlessness...... Instability......
5. Withdrawal from companions? Yes...... No......
6. Withdrawal from parents? Yes...... No......
7. Withdrawal from leadership in group? Yes...... No......
8. Hostility toward society? Yes...... No......
9. Hostility toward members of family? { Mother...... Father...... Sister...... Brother......
10. Tendency to be destructive? Yes...... No......
11. Did any of the girls confide in you? Yes...... No......
12. In what per cent of the cases?..

Any additional information may be written under "Comments."

COMMENTS

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....

QUESTIONNAIRE (For Girls)

Instructions: Do not sign your name. Please check the answers.

AGE:

AGE OF FIRST MENSTRUATION:

Did you experience any or a number of the following changes in behavior a short time before menstruation was established?

1. Loss of interest in: school......, work......, play......, home......, friends......
2. Desire to be alone? Yes...... No......
3. Neglect of creative activity, such as playing piano, painting, etc. Yes...... No....
4. Restlessness...... Instability......
5. Withdrawal from companions? Yes...... No......
6. Withdrawal from parents? Yes...... No......
7. Withdrawal from leadership in group? Yes...... No......
8. Hostility toward society? Yes...... No......
9. Hostility toward members of family? { Mother...... Father...... Sister...... Brother......
10. Tendency to be destructive? Yes...... No......
11. Did you want any person to confide in? Yes...... No......
12. Did you confide in anyone? Yes...... No......
13. In whom did you confide? Mother......, Teacher......, Friend......, Relative......
14. Duration of period..............

Any additional information may be written under "Comments."

COMMENTS

....

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of its director, Dr. Helen Montague. They covered the years 1928–1929, and were for girls twelve, thirteen, and fifteen years of age. Girls in the last year group were used as controls for the first two groups. Each of these cases had complete family developmental and social histories as well as physical and psychological examinations.

TABLE 1

Questionnaires. Percentage of girls in each group showing "negative phase" traits

TRAIT	TRAIT OCCURRENCE FOR TOTAL RETURNS OF QUESTIONNAIRES	GROUP FROM POOR HOMES IN RELATION TO TOTAL RETURNS	GROUP FROM POOR HOMES	GROUP FROM BETTER HOMES
	per cent	*per cent*	*per cent*	*per cent*
Loss of interest in school	35	25	62.5	17
Loss of interest in work	25	15	37.5	17
Loss of interest in play	20	15	37.5	8
Loss of interest in friends	35	25	62.5	17
Desire to be alone	35	25	62.5	17
Neglect of creative activity	35	10	25	42
Restlessness	65	35	88	50
Instability	45	30	75	26
Withdrawal from companions	35	25	62.5	17
Withdrawal from parents	15	5	12.5	17
Withdrawal from leadership	25	15	37.5	17
Hostility toward society	25	20	50	8
Hostility toward members of family	6.25			10
Mother	5			8
Father	5			8
Sister	5			8
Brother	10			17
Tendency to be destructive	30	25	62.5	8
Did any confide in you	40	30	75	17
Percentage confiding	40	30	75	17

RESULTS OF PRESENT STUDY

Questionnaires

One hundred and sixty questionnaires were answered and returned. The results have been assembled in table 1. It was found expedient to distribute the results of the returned questionnaires into the four columns of table 1 in order that the significance of the results may be more adequately revealed and more easily comprehended. The first column contains the percentages of occurrence of the Negative Phase characteristics in relation to the total returns; the second column contains the percentages of the occurrence of these characteristics in the girls from poor neighborhoods in relation to the total returns; the third column contains the percentages of the occurrence of the characteristics in the girls from poor neighborhoods in relation to the total questionnaires returned from schools situated in those neighborhoods; the fourth column con-

tains the percentages of the occurrence of the characteristics in girls from better neighborhoods in relation to the total questionnaires returned from schools situated in those neighborhoods.

Considering the columns one by one, we notice that the largest percentage (65) for the occurrence of restlessness, and the next largest (45) for the occurrence of instability. Loss of interest in school and friends, desire to be alone, neglect of creative activity, and withdrawal from companions, each have the same percentage of 35, while the tendency to be destructive occurs in 30 per cent of the reports. Loss of interest in work, withdrawal from leadership, and hostility toward society, each has a somewhat reduced figure of 25 per cent. Except for restlessness, then, the percentages of occurrence of the characteristics descriptive of the Negative Phase are all below fifty. One would conclude, therefore, that generally the behavior of the Negative Phase is not concomitant with puberty. However, let us consider the data contained in the other columns which contribute toward the make-up of the first column.

In comparison with the first column the second column contains relatively large percentages of occurrence of the traits. This fact is more clearly evident in the figures of the third column which indicates the percentages of occurrence of the Negative Phase behavior in girls from poor neighborhoods in relation to the total number of questionnaires returned from such sections. The majority of figures exceed the fifty per cent mark; restlessness 88 per cent; instability 75 per cent; loss of interest in school and friends, desire to be alone, withdrawal from companions, and the tendency to be destructive each reach the relatively high figure of 62.5 per cent; while hostility toward society receives exactly 50 per cent.

The fourth column shows relatively the smallest percentages of occurrence of these traits, only restlessness receives 50 per cent and neglect of creative activity, 42 per cent. With the exception of instability the remaining characteristics do not receive percentages higher than 17. The higher percentages for neglect of creative activity here than in the other columns may be explained by the fact that in the well-to-do homes the girls are given the opportunity to take lessons in some creative expression, as piano-playing, dancing, painting, drawing, etc. Neglect of these activities, therefore, would be noticed more amongst this group than in that of a poorer group who had no opportunities to develop or train along these lines.

It is also interesting to note that hostility toward parents occurs among the better class girls rather than the poorer class. However, this fact is not so surprising after analysis. It is well known to people in contact with foreign families that the parents have little control over their American born children and the latter have little respect for the parents. Even in the cases where there are strict fathers, the children have their way because the mothers are usually weak disciplinarians, relying on the threat to tell the father. When the father comes home at night, the complaint is forgotten and the child goes scot free.

However, for the closer supervised girl of the better class, the chances for friction during this period of development manifested generally by restlessness are greater and hostility toward the parents is the result.

TABLE 2

M.A., I.Q., and grade status of delinquents studied

	RANGE	AVERAGE	MEDIAN	σ	$P.E._{av.}$
12 year old group. 39 cases (1928–1929 records)					
M.A.	6–11	9.07	9.08	1.29	0.95
I.Q.	50–90	73.98	70.32	10.81	7.72
Grade status	3A–8A	4B–5A	4B–5A	2.4	1.3
13 year old group. 59 cases (1928–1929 records)					
M.A.	7–16	10.72	10.50	1.69	1.19
I.Q.	52–124	78.79	77.37	14.23	8.80
Grade status	4A–9B	6A	5B–6A	2.48	1.46
15 year old group. 44 cases (1929 records)					
M.A.	7–17	11.08	10.72	2.29	1.54
I.Q.	48–120	73.45	71.36	16.71	10.24
Grade status	4B–High School	7A	7A–7B	3.06	2.34

TABLE 3

I.Q. scores for types of delinquency

12, 13, and 15 year old groups combined. 142 cases (1928–1929 records)

CHARGE	NUMBER OF CASES	PER CENT OF DELINQUENCY IN RELATION TO TOTAL DELINQUENCIES FOR GROUPS COMBINED	RANGE	AVERAGE	MEDIAN	σ	$P.E._{av.}$
Sexual delinquency	60	42	48–116	71	71.53	12.14	7.37
Incorrigibility	17	12	53–95	77.35	77.5	10.58	5.07
Truancy	5	3	65–85	77	77.5	7.48	6.25
Desertion	35	24	55–120	83.57	84.50	16.72	12.38
Neglect	16	11	52–124	76.87	76.66	15.09	7.5
Stealing	6	4	60–80	71.67	70	7.45	6.25
Sundry	3	2	68–86	78	82.5	16.27	9.37

The increased hostility toward the brothers of the family would agree with Leal's (3) findings that at puberty girls show increased avoidance of the opposite sex. However, it would be worthwhile to know the ages of the brothers, since many writers have noticed that girls during this period of development prefer older men, because maturing earlier they resent the un-

sympathetic behavior of the immature boy of the same chronological age. Except for restlessness then, Negative Phase behavior is not manifested by this group of girls.

Inasmuch as the majority of the reports contained in column 3 came from the same congested East side neighborhoods as the delinquents studied at the Mental Clinic, it may be assumed that the similar social, economic, and mental conditions obtain for both groups. With this assumption, as we can draw upon the tables describing these conditions of the delinquents.

TABLE 4
Home conditions of delinquent group

CONDITIONS	PER CENT OF CASES
Parents living together	42
Homes without fathers	16
Homes without mothers	15
Both parents absent (living with relatives)	22
Parents not married	5

TABLE 5
Percentage of native and foreign-born delinquents

	PER CENT OF CASES
Native-born children—native-born parents	34.51
Native-born children—foreign-born parents	53.73
Foreign-born children—foreign-born parents	11.76

Table 2 gives a mental picture of these girls brought to court: they are all in the borderline class on the average, three to four years retarded mentally and one to two years backward in school. This general description of their mental development agrees entirely with that of the group observed by Hetzer (8).

TABLE 6
Family income in relation to number of children

FAMILY INCOME PER WEEK	PERCENTAGE OF FAMILIES
Two children per family	
dollars	*per cent*
25	31
26–32	14
33–40	20
41–49	11
50 and above	24
Three children per family	
25	20
26–32	17
33–40	21
41–49	15
50 and above	27
Four children per family	
25	19
26–32	15
33–40	20
41–49	14
50 and above	32
Five children per family	
25	13
26–32	14
33–40	21
41–49	15
50 and above	37

The parental conditions indicated in table 4 show that more than 58 per cent of the children have either no fathers, no mothers, no parents, or the parents are not married. These home conditions are conducive to lack of

supervision. In the 31 per cent of the cases where there is either no father or mother, it means that either the oldest girl, who may be younger than a number of her brothers, supervises the home, or the children are left alone, because the father or the mother must work. No doubt, as a result, the street is the children's playground. Hetzer's (8) group was equally unsupervised.

Table 5 shows that 65.49 per cent of the delinquents are native or foreign born children of foreign born parents, the majority (54 per cent) comprising

TABLE 7

Number and percentage of sexual delinquencies in each year group (1929 records) in relation to the total delinquencies for the three year groups (12, 13 and 15 year old girls)

YEAR GROUP	NUMBER OF SEXUAL DELINQUENCIES	PER CENT OF SEXUAL DELINQUENCIES
12	11	31
13	12	33
15	13	36

the group of native born children of foreign born parents. The behavior of these children toward their parents has already been discussed.

In table 6 are given the economic conditions of the families from which the delinquents came. Thirty-one per cent of these families consisting of husband, wife, and two children, live on twenty-five dollars a week; twenty per cent of them consisting of husband, wife and three children subsist on twenty-five dollars a week. And, unbelievable as it may seem, nineteen per cent of the families, father, mother and four children, exist on twenty-five dollars a week. Forty-two per cent of the families are comprised of six children, father and mother, and have an income of fifty dollars a week.

To sum up, the home conditions of these girls are deplorable, the economic status inferior, and their mental development retarded. No doubt, under these conditions, they would also be undernourished. Although in a few cases the physical conditions of the girls were mentioned, it was not done consistently enough to obtain figures on it.

It would seem then that restlessness and instability generally are concomitants of puberty. The other characteristics of the Negative Phase are manifested by girls who lack self control and good training. As Hetzer (8) observed, the girls in her group also gave vent to their feelings and emotions easily and unrestrainedly. Her conclusions in regard to the occurrence of the Negative Phase characterized by the traits listed in table 1 have been substantiated by the group from the poor neighborhood but not by the group from the better sections of the city. In her conclusion that these characteristics are concomitant with puberty, she failed to specify that these might be applicable only to the group she observed. She generalized the behavior of the observed girls and supposed that the Negative Phase is a stage through which all girls pass.

It may be illuminating to cite the contents of some of the questionnaires characteristic of the two groups. The following quotations are from schools in the better neighborhoods, "I have never experienced any very unusual

cases in my teaching here," and "we notice that girls are irritable at this time, and unusually nervous, but not behavior problems; this irritability ceases when menstruation is established." However, a questionnaire returned from a girls' home states that 50 per cent of the girls lose interest in school, work and play; desire to be alone; neglect creative activity; show restlessness; withdraw from their companions; and become hostile toward society. This hostility toward society on the part of the girls in homes is explained by the matrons by the fact that girls at this period of development become sensitive to living in a home; become resentful and blame society at large for their plight. Girls at this time will also rebel at very strict and what they consider unsympathetic supervision.

This lack of restraint in expression of feelings and emotions at the time of puberty, therefore, may be due to lack of training in self-control, lack of supervision and direction in the child's activities, or lack of mental and social development to realize the offensiveness of his behavior, rather than to the physiological condition which is characteristic of this period of the individual's life.

Court cases

An examination of the court records showed that a majority of the girls were of foreign parentage; i.e., they are the first American born generation of parents born abroad. Table 5 reveals that 54 per cent of the delinquents belong to this group. A great number of the parents are illiterates, both in their own and in the English language. Some are not even able to speak English, although they have been in the United States more than fifteen years. This illiteracy may be the result of lack of opportunity to learn, but after reading the case histories the impression is given that it is due rather to their dullness or inability to learn. In the main, the fathers are unskilled manual laborers of an inferior social status.

The home conditions of these girls are far from favorable as has been mentioned previously. Table 4 makes this fact clear. Thirty-one per cent of the families lack either a father or mother. In either case, the parent is absent all day at work and the children are left to their own devices or to the supervision of the oldest sister. There is, therefore, little supervision of their behavior, direction of their play which takes place on the streets, or knowledge about their associates. In 32 per cent of the 142 cases studied, the mother is working either because the husband is dead, has deserted, does not earn enough to support the family, or is not employed steadily.

Nor are the neighborhoods from which these girls come any better, since their locations are on the lower East side of New York or in other congested areas of the city. Inasmuch as the parents are foreigners who speak little English, they tend to settle in their respective congested national districts, where any attempt at Americanization is unnecessary for them to get along in business or social life.

The pitiably small incomes of the families of these girls is shown in table 6. Thirty-one per cent of these families consisting of the parents and

two children live on twenty-five dollars a week. Forty-two per cent of the families including father, mother and six children subsist on fifty dollars a week. Twenty per cent of the families comprised of father, mother, and five children exist on thirty-three to forty dollars a week. These are some of the deplorable environmental conditions.

An inclusive description of the mental development of these girls can be obtained from table 2. The twelve year olds are in the borderline class, retarded three years mentally and two years scholastically; the thirteen year olds are also in the borderline class, retarded three years mentally and one year scholastically; and the fifteen year olds are in the borderline classification too, retarded four years mentally and two years backward in school. Although the I.Q. scores and Mental Ages of the other two groups are not much higher than those for the twelve year olds, yet their scholastic attainments are greater. This is perhaps due to the practice of promoting boys and girls on the basis of their chronological age rather than on the basis of their mental ability.

Table 3 shows the percentages and I.Q. scores for the same kind of delinquencies for all the three year groups. The sexual delinquencies have the highest percentage of occurrence and their average I.Q. score is the lowest for all the delinquencies. This fact agrees with the findings of Leal (13) that in girls of low I.Q. scores the avoidance of the opposite sex decreases with increasing age.

In reading the cases, the writer came across the expression occasionally that the misbehavior had recently started. It was also found that the girl had but recently established her menstruation. These occurrences were very few, only five or six in the entire group.

From the foregoing consideration of the sexual delinquents, it would seem that the girls of this group are more suggestible for reasons other than merely the physiological. A large number of these sexual delinquents had been raped, but the impressive feature was that they failed to resent these forced relations. Perhaps the charge of rape was an alibi for the judge. Others asked men in the streets for money to buy candy or go to the movies and submitted to the men's advances. Some were initiated into the sexual delinquencies by bad companions. The single characteristic feature of all these girls seems to be lack of social judgment or sensitiveness to social approval or disapproval. This lack of regard for the opinion of others may be the result of a number of factors: insufficient supervision by parents, subnormal intelligence, bad companions, physical inferiority, or debasing surroundings in the home and neighborhood. As so many of these girls were exposed to a number of the above mentioned undesirable factors, one cannot attribute the delinquency to any one of them. Furthermore, many of the family histories mentioned sisters, both younger and older, living in the same environment, and of practically similar caliber, as determined by their school grade attainments, who were sexual delinquents. It seems, therefore, that the cause for the delinquency is to be found in the girl's own individual makeup, which is influenced by conditions and circum-

stances which might not affect others of different makeup.

Because of their intellectual retardation, these girls probably cannot sublimate their sexual desires in intellectual and esthetic appreciations which appear generally as new capacities in the intelligent adolescent. Many of this group had just come out of homes where they had been emotionally suppressed and isolated from normal social contacts. As a result of this environment they are apt to become delinquents when released at the critical time of puberty.

SUMMARY

1. The questionnaire study of occurrence of the Negative Phase traits in pubescent girls showed the highest percentage (65 per cent) for restlessness and the next highest (45 per cent) for instability.

2. Loss of interest in school and friends, desire to be alone, neglect of creative acivitity, and withdrawal from companions, each had the same percentage (35 per cent) of occurrence.

3. The tendency to be destructive occurred in 30 per cent of the reports, while loss of interest in work, withdrawal from leadership, and hostility toward society, each had a somewhat reduced figure of 25 per cent.

4. There was a wide disparity between percentage of occurrence of the Negative Phase traits in girls from poor homes and those from better homes.

5. The occurrence of these traits in girls from poor homes constituted 80 per cent of the total occurrence of hostility toward society; 71 per cent of loss of interest in school and friends, desire to be alone, and withdrawal from companions; 60 per cent of loss of interest in work, withdrawal from leadership, and instability; and 54 per cent of restlessness. Restlessness is about evenly distributed between the two groups.

6. The girls reported showing behavior characteristic of the Negative Phase belong to an inferior social and economic level, have deplorable home conditions, and are of retarded mental development.

7. These girls live in the foreign settlements and other congested areas of New York City.

8. The results of the study of court cases did not show a preponderance of sexual delinquencies during the thirteenth year, although the percentage of sexual delinquencies in relation to the total delinquencies of the twelfth and thirteenth year groups respectively were larger than that for the fifteenth year group.

9. Sixty-five per cent of the delinquents are native-born of foreign-born parents; 58 per cent of them had either no father, mother, parents, or the parents were living together unmarried. Thirty-five per cent of the families consisting of father, mother, and two children, had an income of twenty-five dollars per week; while 20 per cent of the families consisting of parents and three children also lived on an income of twenty-five dollars per week.

10. The majority of delinquents came from the poor, congested areas and East Side of New York City.

11. On the average, the delinquents of all groups were of borderline intelligence. They were retarded two

to four years scholastically, and three to four years mentally.

12. The average I.Q. scores for sexual delinquencies is the lowest of that for all delinquencies and decreases with increased age.

It would seem, therefore, that bad environment, undisciplined up-bringing, lack of self-control, and mental retardation, which are a few of the descriptive conditions of the girls from poor homes, have something to do with the occurrence of Negative Phase behavior, since this group showed high percentages for occurrence of the traits characteristic of the Negative Phase. The group observed by Miss Hetzer (8) were of similar social, economic, and mental status. The fact that the Negative Phase behavior was prevalent among them did not warrant the conclusion that the Negative Phase *is a "necessary concomitant* with puberty." The mental retardation of these girls may be a cause contributing to their misbehavior. No doubt girls of better homes but who have often been pampered would also show Negative Phase behavior. Since their behavior, generally, is wilful and egotistical, the restlessness during puberty would tend to manifest itself in hostility and other traits of the Negative Phase, a mere exaggeration of the normal behavior.

CONCLUSIONS

1. The above data seems to justify the following conclusion: that generally restlessness and instability are concomitants of puberty in girls, but whether this disquietude becomes marked enough to be outstanding depends upon a number of factors, the most important of which are environment and home training. The girls reported showing the behavior characteristic of this phase were from inferior social and economic levels; they lived in poor, congested neighborhoods; were unsupervised in their play and conduct; and suffered from deplorable and undesirable home conditions. Inasmuch as the group Hetzer (8) observed was of similar description, it would seem that the appearance of the Negative Phase in girls *shortly before or during puberty* depends upon environmental factors, and fits in with the suggestion that developmental maturities can be modified by influences from without. Like the child who has not been trained in the proper manipulation of toys will make random movements with them, so the unsupervised, socially untrained phys*iological maturing individual will* express her restlessness in an uncontrolled manner.

2. The occurrence of sexual delinquency, it would seem, may be con*ditioned by a great many factors:* insufficient supervision by parents, subnormal intelligence, bad companions, physical inferiority, debasing surroundings in the home and neighborhood rather than physiological development. Many of the sexual delinquents in the twelfth and thirteenth year groups had had sexual relations with men from six months to two years previous to arrest. Therefore the sexual drive is only reinforced during puberty and not introduced for the first time, since the delinquencies had already occurred before that physiological period of development was reached. Their mental retardation

probably prevents them from sublimating their sexual desires in intellectual and esthetic appreciation which generally appear as new capacities in the intelligent adolescent. But one must not put too much emphasis upon either the immediate environmental factors nor mental caliber as the fundamental factors in behavior. Rather one must look to the peculiar personality of the individual which is played upon by emotional appeal plus concomitant circumstances.

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Brief Reports

The Kohs Block Design Test

THE Kohs block design test was given to 29 children in the Child Institute of the Johns Hopkins University. The subjects ranged in age from two years four months to five years three months.

TABLE 1

Time in seconds

	CHRONOLOGICAL AGE		DESIGN								
	Years	Months	I	II	III	IV	V	VI	VII	VIII	IX
1	3	8	20	35	30.4	46	51	39.4	90	Inc.	18
2	3	10	19	37	21.4	Inc.	66				
3	4	0	73								
4	4	4	25								
5	4	4	26.6	Inc.	31						
6	4	4	25	Inc.	31						
7	4	6	30								
8	4	6	21.4	51	36.6						
9	4	7	37	12.2	19	24	40	16	41	57	36.4
10	4	8	55	36	32	Inc.	41	55	245	40	Inc.
11	4	9	13								
12	4	11	10	Inc.	44	Inc.	25	Inc.	15	24	Inc.
Kohs'	6		72	73	59						
Norm	7		34	72	70	79	92	122	108	76	77

PROCEDURE

Sixteen colored cubes were placed on a table before the child so that the single-colored faces were on the top-side of the cubes; there were an equal number of reds, yellows, blues, and whites. The experimenter pointed to a red-topped block, and asked the child to point to all blocks that had the same color on top. The same procedure was used for the other three colors.

After the child showed sufficient color discrimination, a trial design was formed. Pantomime was used freely, with the subject watching closely. The child was then requested to repeat the operation. This procedure was repeated until the child understood. The blocks were then shuffled so that, when placed before the child, no more than one quarter of the blocks had

top-side colors which were present in the design, the separate blocks being placed apart, flat on the table, and not piled one on top of another.

The child was told: "What you are to do is this: Take these blocks, pick out the right colors; put them together; and make them look, on top, just like this," (pointing to design which was exposed as model). The time and number of moves were recorded.

Designs 1 to 9 were given except in cases of failure on three successive designs, when the test was stopped.

The time scores for the different designs are given in table 1. These scores for individual designs show the ability of some children at an early age to accomplish this performance for which age norms are not given. The test was scored according to Kohs' score chart, using correctness of design, time, and moves as factors. These scores are given in table 2.

No child in the two year group carried out the instructions. The only response elicited was that of piling the blocks.

TABLE 2

Combined scores and age norms

	C.A.		I.Q.	Kohs' score		C.A. norms		M.A.	
	Years	Months		Weighted	Un-weighted	50 per cent	75 per cent	Years	Months
1	3	8	127	49	8	10	14+	12	1
2	3	10	158	17	4	8+	9+	8	10
3	4	0		3	1	6	6+	6	3
4	4	4	121	2	1	6	6+	6	0
5	4	4		5	2	6+	7+	6	9
6	4	4	113	7	2	6+	7+	7	3
7	4	6	117	2	1	6	6+	6	0
8	4	6	116	10	3	7+	8+	7	10
9	4	7	100	55	9	11+	16+	12	7
10	4	8	105	36	7	10	12	11	0
11	4	9	87	3	1	6	6+	6	3
12	4	11	121	27	5	9	11	10	2

Two children in the third year group obtained scores of 17 and 49 respectively. Each had had access to colored blocks in the home.

Ten out of seventeen in the four year group made scores ranging from 2 (first design only) to 55 (all nine designs). Some had had access to blocks, others had not.

Neither of the two five year subjects was able to succeed in any design.

PAULINE EIGLER.

Differences in Measurements Made in the Nude and Clothed For Children between Seven and Nine Years of Age[1]

IT IS often necessary to measure children clothed, especially if a large group is being examined in a few hours' time. The value of such measurements as compared with those made with all clothing removed can well be questioned, but judging from the repeated requests for information about differences found between clothed and nude measurements, their relative worth has been clearly recognized by investigators.

Ninety-seven boys and 67 girls between the ages of seven and nine years were measured during the month of January, 1929 according to the technique described by Baldwin (1). They were boys and girls from homes where all the necessary comforts of living were available, so that the amount of clothing which they were wearing could be considered adequate. The study was conducted throughout the month, during a period when the temperature averaged twelve degrees above zero. By accident rather than design the greater part of the work was done when the mean temperature centered near zero. The clothed measurements were made over such clothing as the children wore in a well heated study hall, with shoes and top coats or sweaters removed. Immediately following the clothed measurement, each child was measured in the nude.

The children ranged in age from six years and six months to nine years and five months. They were separated into year age groups in order to find the average differences between measurements clothed and nude at each age, since the relative amount of clothing worn might be different for the younger and older children. The nude values were then subtracted from the clothed and averaged for each sex. The results are shown in table 1. Height is not included because it was only measured in the nude. They tended toward the upper limits of medium build according to the Baldwin-Wood standards. The difference in weight is expressed in pounds, the difference in other dimensions in centimeters.

A ratio was computed by dividing the difference between the means clothed and in the nude by the probable error of the difference to see whether clothing has a marked effect on measurements. A ratio of 3.0 was considered significant. The findings showed that chest circumference and the antero-posterior diameter were increased significantly by the thickness of clothing in the seven and eight-year-old groups of girls. Width of hips at seven and eight and depth of chest at eight were also increased significantly

[1] This study was directed at the Iowa Child Welfare Research Station by Sarah Idell Pyle and Helen Garside Kelly. See Clark, Grace: The relation of the growth of a segment of the chest to general body growth. Iowa Child Welfare Research Station. Unpublished Master's Thesis, 1929, pp. 87.

TABLE 1

Mean differences between measurements for boys and girls clothed and in the nude

AGE, YEARS	NUMBER OF CHILDREN	WEIGHT	SITTING HEIGHT	WIDTH OF SHOULDERS	WIDTH OF HIPS	WIDTH OF CHEST	DEPTH OF CHEST	CIRCUMFERENCE OF CHEST
				Boys				
7	37	1.69	0.29	0.34	0.61	0.37	0.37	2.04
8	35	1.86	0.29	0.35	0.71	0.34	0.43	1.82
9	25	2.25	0.22	0.22	0.57	0.39	0.46	1.99
				Girls				
7	22	1.39	0.48	0.32	0.48	0.30	0.43	2.05
8	23	1.68	0.40	0.27	0.64	0.32	0.45	2.01
9	22	1.62	0.27	0.28	0.35	0.30	0.43	1.28

TABLE 2

Mean, probable error of mean, standard deviation, and coefficient of variability in nude and clothed measurements

MEASUREMENT	NUDE				CLOTHED			
	Mean	$P.E._M$	S.D.	V	Mean	$P.E._M$	S.D.	V
				Girls				
Weight	54.56	0.88	10.8	19.8	56.13	0.90	10.98	19.56
Sitting height	67.89	0.25	3.06	4.51	68.27	0.25	3.04	4.45
Width of shoulders	28.30	0.17	2.06	7.28	28.59	0.17	2.07	7.24
Width of hips	22.35	0.14	1.68	7.52	22.85	0.13	1.62	7.09
Chest circumference	57.92	0.12	4.90	8.46	59.70	0.37	4.54	7.60
Chest width	19.21	0.12	1.50	7.81	19.52	0.12	1.51	7.74
Chest depth	14.77	0.11	1.39	9.41	15.22	0.11	1.34	8.80
				Boys				
Weight	54.51	0.69	8.61	15.79	56.40	0.62	9.10	16.13
Sitting height	68.50	0.21	3.05	4.45	68.77	0.18	2.70	3.92
Width of shoulders	28.60	0.11	1.65	5.77	28.92	0.11	1.60	5.53
Width of hips	21.94	0.10	1.47	6.70	22.59	0.10	1.51	6.68
Chest circumference	59.14	0.23	3.33	5.63	61.09	0.24	3.50	5.73
Chest width	19.76	0.09	1.26	6.38	20.13	0.09	1.30	6.46
Chest depth	15.02	0.06	0.89	5.93	15.44	0.06	0.93	6.02

for boys. The other measurements were not greatly affected by the amount of clothing.

Two additional ratios were calculated to test the relation of clothing to size. The first was made between the nude measurements of the children at seven and eight, eight and nine, and seven and nine years. The second ratio was made between the clothed

measurements at the same age intervals. The first showed that these boys were significantly larger at each succeeding year except in antero-posterior diameter of the chest when the ratio was 2.6. There was not a similar outstanding difference in the girls from seven to eight years in any of the dimensions studied, but in each dimension the nine-year-old girls were decidedly larger than the eight-year-old girls.

The second ratio was calculated to bring out the differences introduced by clothing. This ratio ran consistently parallel to the first, and one can infer that in this group the clothing probably did not vary much in type from year to year, but varied as the size of the children varied.

Finally the three age groups were thrown together and the variability of the entire group was computed. The results as shown in table 2 were interesting in that the nude and clothed values proved to be so similar in variability. The measurements for girls clothed were even slightly less variable than those made in the nude. The value of these findings would be clarified by a test of the examiner's precision in locating the proper landmarks when the subject is clothed.

SUMMARY

Measurements clothed and in the nude were made for a group of 97 boys and 67 girls from seven to nine years of age, and mean differences in measurements made by the two methods were calculated. The results showed that circumference of chest, width of hips, depth of chest, and weight were affected significantly by clothing.

There was a significant difference in the various dimensions of the boys in the different age groups at this period of growth. The eight- to nine-year-old groups of girls were relatively larger than the seven- to eight-year-old group. Clothing seemed to vary in amount consistently with size.

When each sex group was considered as a whole regardless of age, measurements clothed tended to be no more variable than measurements made in the nude.

GRACE CLARK.

REFERENCE

(1) BALDWIN, BIRD T.: The physical growth of children from birth to maturity. Univ. Iowa Stud., Stud. in Child Welfare, 1921, 1, No. 1, Pp. 411.

Skill in Progressive Movements of Children

IN A study of the development of motor control in children an attempt was made to get measures of the ability of the child to maintain body balance while walking on a raised pathway. Previous observations had shown lack of control in some children who manifested little behavior such as is usually called fear; in some cases fear was apparent at the beginning of the performance which affected the ability in control and sometimes caused a refusal to undertake the task.

The apparatus used was a walking board which has been distinctly modified from the form originally used by Johnson and described in Mental Growth of Children.

TABLE 1

Walking board

NUMBER OF CHILD	CHRONOLOGICAL AGE		LONGEST DISTANCE								TIME							
	Years	Months	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8
			inches	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*seconds*	*seconds*	*seconds*	*seconds*	*seconds*	*seconds*	*seconds*	*seconds*
1	4	8	30	55	35	35	25	40	115	60	27	20	21	16	15	16	14	11
2	4		90	135	60	85					16	8	15	24				
3	4	5	105	55	65						14	20	24					
4	4	4	75	325	135	135					29	34	27	19	18			
5	4	5	95	135	90						23	20	24					
6	4	10	1175	80	675	575					33	30	19	34				
7	4	5	135	50	95	120					11	13	11	10				
8	4	8	135	675	275	50					23	24	22	22				
9	3	7	45	20	35	25	25				74	22	30	24	22			
10	4	4	225	275	35						42	62	62					
11	4	9	135	90	135	135	110				17	13	11	10	15			
12	3	9	475	70	40						38	22	32					
13	4	10	70	65	75	70					13	15	15	13				
14	4		40	25	55						25	42	35					
15	3	11	20	30	40						42	40	31					
16	4	1	35	25	55						64	48	46					
17	5	1	85	135	80						6	12	9					
18	4	3	60	85	75						14	13	10					
19	3	2	15	80	20	50	40				26			17	18			
20	2	8									15							
21	3		5															
22	2	7											Not included in averages					
23	4	3									27	36						
24	3	4	50	40							46							
25	3	7	40															
Total			1,356	1,261	1,219	1,280	200				537	475	462	189	88			
Average.			71.3	66.3	64.1	12.8	50.0				28.2	25.0	24.3	18.9	17.6			

To construct the walking board a pine plank 135 inches long, $1\frac{13}{16}$ inches high, and $1\frac{11}{16}$ inches wide was clamped by angle irons on to a redwood piece 135 inches long, 1 inch high, and $8\frac{11}{16}$ inches wide. At each end were screwed platforms 12 inches long, $2\frac{10}{16}$ inches high, and $9\frac{3}{4}$ inches wide. The redwood board was marked off into three sections to facilitate scoring the child's steps off the pine board. We placed yellow numbers 0 to 9 five inches apart, blue from 0 to 9 five inches apart, and white numbers from 0 to 6 five inches apart.

We instructed the child to stand firmly (with both feet) on the platform. The time was taken from his first step on the entrance platform until he reached the platform at the other end. The tendency of the children was to walk straight (placing one foot ahead of the other). One child, however, walked sidewise after failing the other way.

The plan was to count the distance where the child first stepped off and then get him to start over. It was found that the children wanted to walk to the end so the score was taken of points stepped off, total distance (usually 135 inches) walked, and longest distance walked before stepping off. The time required for the performance was kept with a stop watch. The results for individual children are given in table 1.

Six children increased the total distance walked with second and third trials. Others became excited or nervous after first trial and did not walk so far without stepping off. There were five in this group. Three children showed a good performance in all trials. Seven children showed variability in performance from trial to trial. One child, a boy of four years three months, refused to walk; another attempted to walk but after stepping off refused to continue first trial; one other refused to do more than one trial. There was one case of a boy's refusing to do more than two trials. Two of the children in the youngest group appeared unable to accomplish this performance.

The board appears to be promising as a measure of individual differences in body movements within a given age group and in comparison of development from year to year. The emotional elements of behavior play a large part in the variability of performance. This requires more difficult technique for obtaining measurements of motor skill but also offers an opportunity for study of emotional responses.

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Children's Choices in Modern Art

ELEVEN reproductions of modern paintings were hung on a wall on a level with a child's eyes. The pictures were arranged in order from the most impressionistic to the most realistic and numbered from one to eleven as given below. Each child was placed in front of the pictures and told, "Here are a lot of pictures. Look at them all and show me which one you like best." When one had been pointed out he was prompted to choose

others by being asked, "What other ones do you like?"

RESULTS

Fifteen children were tested, 4 girls and 11 boys, ages three years five months to five years five months. The following is a list of the pictures, giving their titles or subject matter and the number of children who chose each. First to fifth choices were counted when the pictures were really picked out from the rest, but only the first and second choice was used when the child merely pointed to the pictures in order.

1. The Procession (Cubist)	2
2. Improvisation	3
3. Figures on horseback	2
4. Women	0
5. Man on Balcony	2
6. The Goldfish	3
7. Women in garden	0
8. Ball at Arles	2
9. Horse Attacked by Jaguar	6
10. Ship at dock	11
11. Group of women	9

After picking out their first choice 5 children said that they liked all the rest and 7 children pointed to practically all of the pictures in order. Only 3 chose less than ten pictures. Picture number 10 was chosen first by 9 children. No other picture was given first choice by more than one child. Number 10 is a boat picture, numbers 9 and 11 were next in popularity. All three of these were the most realistic of the group. But the choice of 9 and 11 may be due in several cases to their proximity to 10.

CHOICES IN CHILDREN'S DRAWINGS

Twenty-eight children 14 boys and 14 girls, from the Institute of Child Welfare, University of Minnesota, served as subjects. Their age ranged from two years four months to four years eleven months. I.Q.'s from the Kuhlman-Binet and Minnesota Tests were from 85 to 162; M.A. from two years four months to seven years five months.

Ten spontaneous crayon drawings of 5 four-year-old children of the Child Institute of the John Hopkins University were used for presentation. A record had been kept of what the picture was supposed to represent according to the child who drew it. The child was seated in a small chair at a low table with the light from above. The pictures were placed before him on the table one at a time with the instructions, "Tell me what is in this picture," and the added question, "What else?" when the child hesitated. If he pointed at a part of the drawing without naming it, he was asked, "What's that?" When urging was needed to make the child speak, the experimenter repeated the above phrases modifying them as, "Tell me what that is," and "What else is in the picture?"

A record was kept of everything the child named in the picture. From this 3 scores were compiled: (a) the number of pictures correctly named, that is, the number of the times the child named a picture in accordance with the description of it given by the child who had drawn it; (b) the number of objects or parts of pictures correctly named; and (c) the total number of objects named. Details named were counted as separate objects. But calling a picture merely "picture" or "crayons," or naming the colors was

not counted in the score. Nor were repetitions of the same name for the same object in a picture counted. Any name which approximated the correct one was accepted as correct. Thus "girl," "boy," "dolly," and "clown," were counted correct names for the drawing of a human being.

In two of the pictures none of the children was able to recognize an object. The two pictures which were the easiest to name had drawings of people in them. The three which ranked next easiest were of houses.

Two children were unable to name any picture correctly. One child, the youngest, named no objects at all but merely said colors. There was a larger tendency to name colors among the younger children, centering around the age of three years four months.

The largest number of objects correctly named by one child in all ten pictures was 14, the largest total number named by one child was 34. Several of the children would call successive pictures the same thing, for example "marbles" or "beads." The older children were interested in who made the pictures, asking about them. One boy jokingly named the man incorrectly, calling him a dog and the legs his *two* tails.

Pearson's formula was used to compute the correlations by the method of rank differences. The coefficients are given in table 2.

TABLE 1

	PICTURE NUMBER									
	1	2	3	4	5	6	7	8	9	10
(a) Children naming one or more pictures correctly	10	0	17	0	12	19	23	5	19	21
(b) Objects or parts of pictures correctly named	11	0	39	0	12	20	32	7	21	37
(c) Total objects named	30	24	54	25	50	39	58	33	42	58
(d) Different objects named	20	21	21	14	29	19	32	20	19	29

TABLE 2

	SCORES		
	C.A.	M.A.	I.Q.
Pictures correct (a)	0.78 ± 0.06	0.77 ± 0.06	0.22 ± 0.11
Objects correct (b)	0.75 ± 0.06		
Objects named (c)	0.64 ± 0.08	0.74 ± 0.06	0.40 ± 0.11

The drawings of children appear to have greater significance for other children than have the compositions of modern artists. There is also a relatively large degree of *universality* in the names given by children to the *spontaneous productions of other children* of approximately the same age and environmental status.

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Author and Subject Index